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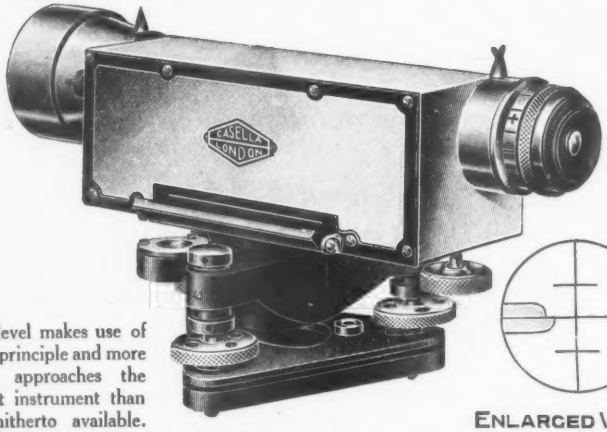

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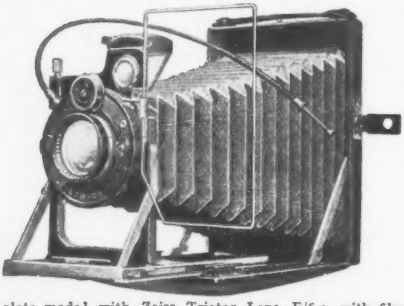

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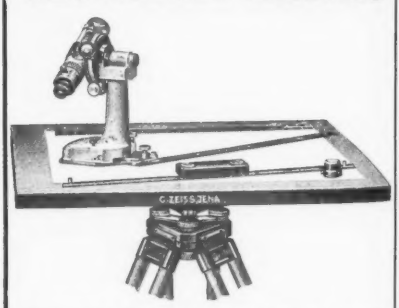

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The GEOGRAPHICAL JOURNAL

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EXPLORATION IN THE INTERIOR OF PAPUA AND NORTH-EAST NEW GUINEA: THE SOURCES OF THE FLY, PALMER, STRICKLAND, AND SEPIK RIVERS: *A paper read in part at the Meeting of the Society, 7 January, by Mr. A. F. R. Wollaston for the Author*

C. H. KARIUS, A.R.M.

ON 3 December 1926, after several weeks' preparation and outfitting, a start was made from Port Moresby, on the first of my two expeditions to the interior of New Guinea. Although we were not successful in crossing the main range forming the watershed of the streams flowing north and those flowing south, much new country was broken and considerable data of geographical interest were obtained.

Little need be written of the early stages of the journey, made in comparative comfort and ease by boat. From the mouth of the Fly River to a point 512 miles upstream where we disembarked, not a mountain was seen. At this point the river is only 60 feet above sea-level. The Fly is tidal for a distance of about 100 miles, and for a period of three days before and three days after the full moon navigation for small craft is apt to prove dangerous. Owing to the great width of the estuary of the river, 60 miles, and the sudden narrowing of this to the river proper, funnel-wise, the waters of the high full-moon tides are forced up against the river at such a rate as to form a wall 6 to 8 feet high and stretching from bank to bank. This bore, or *abora* as it is termed by the natives, if occurring when the river is in flood, causes considerable damage to the villages and gardens on the river banks; and from the 70 to the 100 mile mark, where the river-banks are only moderately high and the country very flat, flood waters extend for miles inland.

For a number of miles at the tidal limit the river is studded with islands, and above it the nature of the river and character of the country change to huge grass plains, chains of lagoons extending for miles, swamp, and patches of forest. Just above the 200-mile mark the Strickland River flows into the Fly from the north-east. From here on for a distance of 120 miles the river winds by long straight stretches and many big curves through grass country ribbed by low ridges. From the 70 to the 320 mile mark no permanent settle-

ments are seen on the river-bank, but there are occasional glimpses of villages several miles in from the stream.

Abruptly the grass country is left behind and one passes through forest country, which can be divided into two classes, old and new. On the concave side of the river the old forest extends to the river-bank, which is sheer and from 8 to 12 feet high. On the convex side the old forest is generally a good distance in from the river, the space between being covered by a younger growth or new forest.

Below the junction of the Alice and Fly rivers, at about the 460-mile mark, the nature of the country and character of the river again change. The river is narrower, with no long straight stretches and big bends, nor alternation of concave and convex banks with old and new forest. To the forest trees are now added the Pandanus, tree ferns, breadfruit trees, and an occasional sago palm, the whole appearing in a wealth of vegetation, vines and creepers.

Arriving at a point below Macrossan Island, 512 miles up the river, my party and stores for six months were landed, the boats leaving for the coast next day, December 19; and now commenced the heart-breaking task of transporting our stores overland. Not yet had we obtained even a glimpse of the mountain range for which we were making. Progress was terribly slow, and it was not until 8 March 1927 that we arrived at the junction of the Black and Palmer rivers, the 590-mile mark: two months and three weeks to accomplish 78 miles.

Here we obtained our first view of the mountain range we hoped to cross, still a long way ahead of us. Gradually the nature of the country was changing; no longer were there wide unbroken stretches of flat country, but many ridges had to be climbed and the intervening valleys crossed and creeks bridged. We were steadily working north and north-east. By April 2 we had arrived at a point 620 miles up the river and within 6 or 8 miles of Mounts Blücher and Donaldson, and it was here that our greatest difficulties were encountered. A belt of limestone country stretched before us, over which it seemed almost impossible to travel.

In 1890 Sir William MacGregor made an expedition up the Fly, to its junction with the Palmer, and on up the latter to the 615-mile mark, 5 miles below my present camp. Bearings on the Victor Emanuel Range were obtained, and the positions of Mounts Blücher and Donaldson were fixed. From a study of his map it seemed safe to assume that the Palmer passed between these two mountains on its way down from the Victor Emanuel range, and it was at this point I decided to endeavour to find a way through to the main range.

The Fly and Alice rivers lying to the west of Palmer had already been explored to the 600-mile mark, where an impassable limestone belt was reported.

For many days we were hung up at our 620-mile camp while the country ahead of us was explored, our objective being a pass through to the north of Mount Blücher. Mount Donaldson (2000 feet) lay on our west, and Mount Blücher, a huge precipitous wall of limestone 5000 feet high, to the north-north-east of us. It was quite obvious that the Palmer had its origin to the north of these two mountains, and to find a way through was the task confronting me. To follow the river proved impossible, as it ran through a gorge

miles long and with walls in places rising sheer for hundreds of feet. The country back from the river was so broken that travelling was almost impossible: one maze of ravines and crevices running in all directions and ending as abruptly as they began, with streams flowing north, south, east and west. Many of these I endeavoured to follow, and always with the same result: good travelling for a few hundred yards, and then the stream would disappear and my party would be brought to a halt against the face of a sheer wall of limestone.

I next tried to work along the tops of the ridges, trusting to chance that one would lead us away in a northerly direction. The travelling here was extremely dangerous owing to the many holes and crevices, most of which were so well covered with a matting of tree-roots and moss as to be quite indiscernible. Not until one's walking-stick pierced the mat or one of the party put a foot and leg through, was the presence of danger made evident. Many were the narrow escapes from accident.

The following is an instance of our rate of progress in a desired direction: From our camp could be seen, about 300 yards farther upstream, a wide sandy beach, past the end of which flowed a large stream of water coming in from the east. I decided to visit this spot and endeavour to follow the stream to its source, obviously in Mount Blücher. This stream I have named the Len. A start was made from camp at 6 a.m. Three hours later, after many detours and false starts, we came out on to a large stream 50 to 60 yards wide and very deep, which I subsequently found to be the Len. This we followed to its junction with the Palmer, arriving there after much strenuous climbing and many detours, at 4.30 p.m. Ten and a half hours' travelling gained our objective only 300 yards from the camp. The return trip to camp, swimming and fording, took under ten minutes.

Seeking for a pass over or around Mount Donaldson, we found the country so broken and rough, and the coral limestone so severe on my barefooted carriers, that the attempt had to be abandoned. So we decided to follow the Len upstream to Mount Blücher. This was eventually accomplished, and camp was made at an altitude of 1600 feet.

The next undertaking was to cross Mount Blücher or to find a way around. Several attempts were made at scaling the mountain, but never did I manage to pass the 2300-feet mark. From this point rose sheer walls of almost bare limestone, affording neither foot nor hand hold. Trying to the west, we found the travelling was extremely rough, so we decided to try for a pass to the east. Passing the headwaters of the Len, on the third day we came to the source of the Black river, commencing as a small trickle in the side of Mount Blücher and approximately 2000 feet above sea-level. From here on the travelling became so difficult that I realized it would be out of the question for laden carriers, and decided to try again for a pass around the western end of Mount Blücher. This was eventually accomplished and camp established on the Palmer to the north of Mount Blücher on April 15.

Leaving my companion, Mr. Champion, to bring forward the stores and camp gear to this point, I, with a small party of carriers and police, set out to trace the Palmer to its source, and if possible from there to cross over to the Sepik watershed.

Shortly after starting we came to a junction on the Palmer, one branch, known as the Luap, coming in from the north-north-west, the other, the Tungom, from the north-east. As this latter appeared to be the larger or main stream, I decided to trace it to its source. Towards the end of the first day's travelling we came to a bifurcation of the Tungom, one branch coming from the north and the other from east-north-east. Choosing the latter, as I considered it the main stream, we followed it to its source in Mount Tungom, arriving there towards noon the following day. I later found this was not the main branch of the Tungom, so named it the White River, from the milky-white colour of the water and the nature and colour of the country through which it flowed, many terraces of snow-white limestone, one rising above another, flanking the stream on both sides. The river finds its source 2600 feet above sea-level in a huge landslide in the face of Mount Tungom, which is joined with Mount Blücher by a ridge running north-east from the latter.

Striking north from here, we crossed a divide at 3000 feet, dropped into a valley and crossed a stream flowing south-west. This I subsequently found to be the main stream of the Tungom, and traced it to its source to the north in the Dap range at an altitude of 3500 feet. Again climbing we crossed another divide at an altitude of 6000 feet, and at 4500 feet we had come clear of the limestone formation, the rock now being a brown, soft sandstone. After crossing the divide we followed along a spur running north and gradually descending, until we arrived at a large stream flowing away to the north-east. It was very rough country in whichever direction one looked, huge mountains on all sides, and it was quite impossible to obtain an extended view in any direction. Believing that I had come on a tributary of the Sepik I decided to follow this watercourse, so, returning to my camp on Mount Blücher and finding Mr. Champion had completed the transport of stores to this point, I set about preparing for a dash to the Sepik and the coast on the northern side of New Guinea.

Owing to the terrible transport difficulties I decided against taking the whole party with me. Picking out twenty of the strongest carriers and six police, on May 1 I again set out for the Sepik. Arriving at the farthest point reached on my former trip, I first of all traced the stream to its source to the west-south-west, and then commenced the journey downstream. For ten days we struggled against almost unimaginable difficulties. The watercourse was too rough for travelling, and we were forced to climb mountain after mountain, clamber across the face of cliffs 2000 and 3000 feet above river-level, cross landslides, which in many cases commenced to move ere my party had crossed, and build lawyer-cane suspension bridges to cross and recross the river.

After several days of this it became apparent that the river we were following was swinging away from its northerly course to the east and slightly south of east. I then realized that we were not on the northern slope of the Victor Emanuel range, and came to the conclusion that we were on the Strickland river, making back for the Fly and the south-western coast of Papua. We had gone too far to turn back, so I determined to continue down the length of the Strickland to its junction with the Fly and so to the coast.

On May 13, when our stores were beginning to run low, we came to what

Mount Donaldson, looking south-west from Mount Blücher

Looking south from Mount Blücher

Mount Blücher from upper White river

Palmer river above 625 mile mark, flowing between limestone walls

Steep wall of Mount Sare, with limestone laid bare by landslides

Upper reaches of White river: Mount Tungom landslide in distance

at first glance promised to be an impassable barrier. The river plunged into an immense gorge, the length of which I had no means of ascertaining. We had come to the point where the Strickland cuts a way through the mountains between the Blücher and Müller ranges, and so out into the plain country to the south. This time there was no question of finding a pass around the end of the mountain; we must find a way over. Two days were taken in finding a way, and great was the relief of all hands when it was accomplished. The memory of our ten days' experience in tracing the course of the Strickland through the mountains, where landslides were of daily occurrence and earth-tremors frequent, remains with me yet as one of the most nerve-trying I have ever undertaken.

Having eventually crossed the mountains we again had to traverse the comparatively low-lying limestone belt to the south. As however we were travelling downstream I did not fear greatly on this score, for we should be able to raft as soon as the river became slightly less turbulent. Coming on a stream flowing from the north-west, which I have named Murray River, we travelled down it. Food supplies were running low, and to expedite matters I began rafting earlier than was really advisable, with the result that many capsizes occurred, rafts were smashed, and gear lost; and it was not until May 22 that we came to the junction of the Murray and Strickland rivers. The Strickland is a very large river at this point and swift flowing, with many rapids and whirlpools. Some very exciting incidents enlivened the next two days, until we arrived in calmer waters, in conditions like those on the Fly. Rations had quite given out by this time, and from here on until June 9 we subsisted on sago and such game as we could shoot.

Arriving at the Government Station, Daru, on the coast to the south-west of the Fly estuary, I learnt that Mr. Champion had not yet returned. After I left him at Mount Blücher he made a patrol up the other branch of the Palmer, the Luap. This he traced to its source, and then working west, crossed a divide and came on the source of the Bol river, a tributary of the Fly. Continuing westward he came to the Fly, or Feneng (native name). This he did not trace to its source. Becoming somewhat anxious as to the welfare of the party left in camp at Mount Blücher, he retraced his steps to the camp, and then with all hands set out on the return trip down the Palmer and Fly to the coast.

Thus ended the first expedition. The sources of the Palmer and the Strickland had been located; two new streams, the Len and the Murray, discovered; and a pass through the limestone belt right up to the main range established. Three probable passes across the divide were also located.

Armed with these data, a second attempt at crossing the divide should prove, comparatively speaking, an easy matter. What lay beyond, what difficulties were in the way, and if we would be able to carry sufficient food to see us through, remained to be found out. After crossing the divide it was more than 700 miles to the coast.

On 17 September 1927, having re-outfitted and obtained fresh carriers, a start was made on the second expedition. My plan of operations was considerably modified. On the first occasion I trusted to a small party of carriers

to see me right through. This time I had a picked party of thirty-six carriers to go through with, and brought my party up to 100 with carriers collected at the mouth of the Fly River, to be returned to the coast after having assisted with the transport as far as my former camp on the northern slopes of Mount Blücher.

During the transport of the stores some of our trade tomahawks were stolen by natives from our first camp beside the Fly river. Some days later, therefore, across the Black river, I decided to take no risks with a number of local natives who came into the camp. At the finish of the day's work all axes and knives were collected and stacked under some gear in the centre of my tent. I was awakened at midnight by something bumping under my bunk. My first thought was of the axes. I switched on my torch, and sure enough there was a native bending over them. Another native was under my bed, and a third half inside the tent. The axes were being passed from one man to the next, and so to the natives waiting outside. There was an immediate scatter when the torch was switched on. The man under the bed, however, failed to get clear quite quick enough. I managed to catch hold of him, but was unable to get a good grip. His struggles to get away were strenuous, and long before the police, in answer to my calls, arrived on the scene, he broke free and fled, but left his axe. The loss of the axes was serious, as we had only twelve for the whole trip.

By November 14 all stores had been transported to the camp north of Mount Blücher, and all but thirty-six carriers and six armed constables were sent back to the coast.

Despite the fact that only three or four months had elapsed since the road to this point had been cut and bridges built, there was little of all that work in evidence now, so rapid is the growth of vegetation and swift the decay of fallen timber.

On November 18 began the next stage of our journey. I decided to follow the Luap to its source in the Dap range to the north of our camp, then swing west, skirting the range and crossing a spur running south from it, and so drop on to the headwaters of the Bol, which flows into the Fly river.

After leaving our camp at Mount Blücher, instead of following the Luap around the eastern side of Mount Mabiom, we skirted the mountain on its western side, crossing a ridge at 3000 feet before again descending into the valley of the Luap. There was a splendid view from this ridge down the valley of the Luap, with, in the distance, the upper reaches of the White river and the huge landslide in Mount Tungom, where the White rises, bearing 109°. Behind this and continuing east, was the high white wall of the Blücher range. In the far distance and still farther east and a little south could be seen the valley of the Strickland where it cuts through the Blücher range, probably the gorge described above, which we called "The Devil's Race."

Descending from the ridge we crossed the Luap at an altitude of 2500 feet in water icy cold. Ducks of a small brown variety were seen here. Travelling north-west we camped that night in an old garden at an altitude of 3750 feet, with a splendid view of Mount Sare, a man-o'-war shaped mountain, bearing 242°. This mountain was about 6000 feet high.

The following day, still travelling westward and parallel with the Dap range,

we made camp at an altitude of 5440 feet, the range towering another 3000 feet above us, running north-east and south-west. The spur over which we had to pass at an altitude of 7000 feet ran south and about 3 miles to the west of us, and Mount Faim rose up almost sheer from the pass to 11,000 feet, bearing 311°. The Luap finds its source in the Dap range at an altitude of 5000 feet, and about 1 mile east of Mount Faim.

From our camp to the east of Mount Faim the climbing was very stiff to the pass crossing the ridge running down from it. Our general direction was west-south-west, and we reached 7000 feet. A few minutes after crossing the divide and whilst descending westward we came on a small dry and very stony river-bed, the head of the Bol river, which runs west and joins the Feneng. At 6500 feet the first sign of water was seen, just a small stream which after flowing for 12 or 15 yards disappeared underground, and was not seen again until we descended to the 5500-feet level, where water was rushing into the stony river-bed from all directions. In almost no distance at all the Bol was a large stream, flowing swift and strong.

Crossing to the northern side of the stream we travelled slightly north of west, gradually working away from the Bol and steadily descending to Bolivip village on November 25. Several days were spent here, resting the carriers, securing information as to the route north across the range, and endeavouring to obtain guides. We had no interpreter for the language of these people, so all information was gleaned by signs. I learned we had a five-days' journey ahead of us to cross the range, three of which were dry stages.

The houses in the village were miserable little shacks, consisting of one room about 10 or 11 feet square. The floor-level was from 1 foot to 30 inches above the ground; the roof was of Pandanus leaf. In the centre of each house was the fireplace, fenced off by four uprights running to the roof and leaving little room for the occupants. The Bolivip natives are mainly clean light brown in colour, though numbers are dark skinned. They are of average height, and are deep chested, with well-developed limbs. Among other ornaments they wear large concave pieces of mother-of-pearl shell suspended from a chin-strap, or small pieces of shell fastened on the tip of the nose with twine passed through two holes pierced in the nostrils. The young men wear their hair plaited and bound in one pigtail, or sometimes in a number of small pigtails. When we visited the village there was evidently a severe shortage of food, and the natives were very distressed at being unable to make us adequate presents of pig and taro.

On November 27, having secured guides, we moved off from Bolivip, travelling north, direct for a great bluff known as Mount Map, the south-western end of the Dap range. Within fifteen minutes of leaving the village we began the ascent at an altitude of 3600 feet, and at noon we had climbed to 6500 feet: hard travelling and often difficult, and on occasions dangerous. Hands as well as feet were brought into action up an almost vertical wall, clinging to small knobs of rock and roots of bushes, swinging from crevice to crevice. A mistake would have proved fatal not only to oneself but also to those directly in line below. I was immensely relieved when all hands arrived at the top without mishap: a splendid performance on the part of the carriers. Owing to a heavy mist we could see none of the surrounding country, and

were thus unable to take bearings on any of our well-known landmarks, which was very disappointing.

Travelling northwards we came to Amil Creek, which flows south-south-west to the Bol river: just a dry watercourse, a chain of deep pot-holes and strewn with huge boulders. Travelling up the Amil we came to an immense cave, where our guides informed us we must camp for the night at 6328 feet, with the temperature 62° F. at 5.30 p.m. I was somewhat perturbed as I could not see any water, but a search slightly higher upstream located a string of pot-holes filled with water from a seepage high up on the side of the creek. The following day we struck camp at 6 a.m. and continued up the Amil. For the first forty minutes travelling was fairly easy, although one had to go cautiously owing to the waterworn limestone boulders. As we ascended the sides of the creek closed in on us, growing more and more rugged and precipitous as we advanced, and the travelling became more difficult. In places it was necessary to construct ladders and pass the gear up, the carriers following empty-handed.

After three hours' travelling north-east and east we arrived at 7500 feet, and were still in the creek-bed. Gathering from our guides that we left the Amil at this point and climbed to a plateau over which we would have to travel a long distance without water, we decided to make camp where we were, as a string of pot-holes with water in them lay just ahead of us. The country was very rough limestone thinly covered with vegetable soil. The altitude of the camp, 200 feet above the stream, was 7750 feet, and the temperature at 6.20 p.m., 56° F.

Expecting a dry stage on the morrow, we cooked an extra day's ration of rice for all hands, and were on the move by 5.30 a.m. the next morning (temperature 54° F.). At 8.40 a.m. we reached 8900 feet, and travelled steadily north at the same altitude until 9.45 a.m., when we began to descend, not however in one long descent but in a series of ups and downs, each ascent somewhat less than the last and each descent somewhat greater. At 11.30 a.m. we halted and served out a portion of the cooked rice to the carriers. It was extremely cold, so we did not rest long.

The travelling up to this point had been bad and even difficult, but from here on it grew steadily worse: broken limestone with knife-like edges; crevices 50 to 100 feet deep spanned only by a few moss-covered roots or a fallen tree; sudden sharp descents and equally sharp climbs, into and out of a series of large pot-holes or depressions, varying from 50 to 150 yards across and from 80 to 200 feet deep; and other obstacles too numerous to describe. These depressions, running in chains and gradually working to a lower level, are the only visible indication of the direction of flow of the subterranean streams.

From noon until 3.30 we travelled north-east and east; then made camp and served out the balance of the cooked rations. No water was seen throughout the day: a bitterly cold night in camp at 8300 feet.

We were on the move again by 6.10 a.m. next morning, travelling in a general direction between north and east over country similar to yesterday's. At 7 a.m., after a particularly difficult scramble and climb over a mass of broken limestone, we came to what appeared to be an impassable wall of rock,

crowned by needle-pointed pinnacles. Just as I was wondering what possible hope there was of surmounting this obstacle, a turn in the track disclosed the solution to the problem. In front of us was a tunnel through the wall of rock, between 12 and 14 feet long, 4 feet wide, and 10 feet high. The floor was level, the roof arched. Suspended from the roof and rising from the floor were numerous stalactites and stalagmites of lengths varying from 1 to 18 inches. The height above sea-level of this tunnel is 8300 feet. Pushing on at 8.45 a.m. we obtained a view of a huge tabletop mountain bearing 83°, and towering several thousand feet above us. Our altitude was 8200 feet, and I estimate Mount Tabletop to be 11,000 feet. This mountain was seen from the heights above our camp at Mount Blücher bearing 329°.

Our road seemed to be heading for a point to the west of Tabletop, and would probably cross the divide at a saddle which could be seen bearing almost due north. Camp was made at 8159 feet: temperature at 6 p.m., 54° F. We were on a ridge forming the eastern side of a valley running south from Mount Tabletop and heading about 2 miles north-north-east of us.

The headwaters of the Strickland are on the eastern slopes of this same mountain, the valley running away north-east and then east from there, the range of which Tabletop is a portion forming the northern side of the valley, while the southern side is bounded by a range averaging 7000 feet. This valley had been explored by me on my first journey in May.

Striking camp at 6.45 a.m. on December 1, and travelling northwards, climbing steadily, we came to a pass to the west of Mount Tabletop, and crossed the divide into the Takin or Sepik basin at an altitude of 9000 feet, terribly disappointed at not being able to obtain a view owing to rain. This however ceased at 9 a.m., and shortly after we had sunshine. At 10.15 we passed out of the timber belt on to a small grass patch. What a panorama met our gaze! Never before have I seen anything so wonderful. We were at a height of 7150 feet and commanded a most glorious view of the Sepik valley. For at least 20 miles straightaway to the north-west it ran, flanked on either side by mountains at a good distance back from the river. Closer to us and seemingly underfoot was a broad and beautiful basin into which two valleys came from the east and the west. The valley from the east carried the waters of the Sepik, rising in the Victor Emanuel Range, while the valley from the west brought the waters of a river rising in the north-eastern slopes of the Star mountains. This river I subsequently learnt is the Nunk. The Sepik, or Takin, and the Nunk meet in the large basin just mentioned, and then flow away to the north-west.

To describe all I saw during the hour and a quarter spent on the look-out is quite beyond me: huge mountains rising tier above tier, dome shaped, peaked, or bluff and tabletopped, a perfect maze of valleys, grassy plateaux, many villages and gardens. The rock formation on this side shows a striking contrast to that on the southern watershed. No longer are great splashes of white limestone to be seen on the sides of the mountains. Where landslides have occurred the exposed mountain-side shows brown or red. The valleys appear to be very fertile, as evidenced by the many large gardens dotted about everywhere, and the large population here as compared with the sparse population on the southern slopes. What a district to explore and map! How I

longed for unlimited stores and time, and what a distressing thought it was to realize that I had rations for only sixteen or eighteen days, and must hurry through without delay!

Shortly before noon I reluctantly gave the order to move on, wishing I could spend the whole day at the look-out, as new wonders seemed constantly to be unfolding. In the valley below us lay the district of the Feramin people, our objective for the evening. A two-and-a-half hours' descent brought us to the Sepik, a swift-flowing stream 3 feet deep and about 25 yards wide, where the altitude above sea-level was 4735 feet by boiling-point thermometer.

Upstream could be seen our old friend Tabletop Mountain, bearing 116°. The Sepik rises in the north-western slopes, while a branch known as the Lutap comes down from the western end of the Tabletop. It is up the valley of the Lutap that the road or pass runs to the Upper Strickland district, which I visited last April and again in May. The distance across from here was not great: certainly not more than two days, and probably only a single stage. How close I was to the Sepik watershed on the first expedition! In a direct line, 6 miles at the utmost.

From December 1 to January 19 we worked our way down the Sepik valley. We had rations for only sixteen days, so could not afford to delay; but it was fifty days before we came to the October river at the 512-mile mark up the Sepik, where we were met by the *Elevala*, a motor vessel sent round from Port Moresby to meet us.

Two days after reaching the Sepik we came upon our first Feramin village—very neat and clean. The houses were similar in type to those of Bolivip, but were much better built and considerably larger. At one end of the village and enclosed with a wooden fence, closely planted with crotons, was the men's dubu. Behind this and also in the enclosure was what appeared to be a seclusion house. All over the front wall and door of the dubu were many designs, painted in red.

We remained for a short time in the village while the womenfolk presented a few small pieces of baked taro. Then continuing a short distance, we left the river flats and began to climb into the lower spurs of the range bounding the northern side of the valley. Eventually the road led back to the Sepik, but we were soon again forced to climb away from the river.

Ascending in an easterly direction we entered on grass-covered hills. Still climbing, we came to an immense grassy plateau, truly a wonderful sight, with seemingly miles of perfectly level grass plains, evidently more or less a huge swamp in wet weather. Here and there dotted over the plateau were small clumps of timber. These on closer inspection proved to be the heads of gullies or ravines. Quickly the ravines increased in depth, until they were so deep that, although thickly timbered, the treetops were not visible from the level of the plateau. Travelling north for about an hour and fifteen minutes we came in sight of the first Kelafomin village, which kept a very poor look-out. My whole party was in view for fully ten minutes, yet the alarm was not raised until we actually entered the village. Then there was excitement and shouting, a rush for the houses, and a hurried shutting and barricading of doors.

After a few moments, probably after the first shock of surprise had worn off, and seeing we made no effort to harm them, one or two doors were

opened and heads pushed forth. Repeated calls of "Seno, Seno," eventually met with a response, first one and then another native coming out to have a look at us, shake hands, and greet us with the word Avino (friend). The word Seno (friend) is understood by these people, but is not in general use, Avino taking its place. We found this to be our password for a good distance down the river.

We distributed a quantity of tobacco (sauk). At first our friends failed to understand how to make use of it, holding the sticks of tobacco over the fire, scorching it, and passing it back to us again. Then some kindly gentleman rolled a cigarette of native tobacco, lit it, and passed it to me. Having seen the cigarette made and lit, and not particularly liking the process or the brand of leaf, I passed it on to one of the police, at the same time instructing him to make a cigarette out of the trade tobacco and give it to the native. After a practical demonstration our friends quickly understood the use of the trade, and where they were at first indifferent were now all eagerness to possess some. A request for iman (taro) resulted in a great deal of excited talk and shouting, but very little taro. A few pieces of baked taro were given us, but this small quantity amongst my crowd of carriers vanished almost before it was seen. Later in the afternoon I learnt definitely that here also there was a food shortage.

Whilst we were in the village some women and children came in from their day's work in the gardens, with big bundles of wood on their heads, but very lean-looking bags of food slung on their backs. Of ornaments they wore practically none except a piece of wood or bamboo in the ear-lobe. The men were dressed and adorned like all the other mountain people we had seen from Mount Blücher to here.

The village consisted of fourteen houses, in two rows, facing each other. The dubu and seclusion house, built at the end of the village, faced down the lane between the houses. As in the Feramin village, the dubu is fenced off and surrounded by ornamental trees and shrubs. The houses are square, averaging about 15 by 15 feet, built on piles, but not high off the ground. The walls are double and lined with bark. The door-frame is made of one large slab of timber adzed and burnt down to a thickness varying from 1 to 3 inches. The slab of timber is about 3 by 5 or $3\frac{1}{2}$ by 5 feet. An oval-shaped hole is cut in this, which serves as doorway.

Another slab of timber or piece of bark, to close this doorway in case of emergency, is kept inside the house. We had an example of how quickly they can shut themselves in, when we arrived in the village. Evidently the houses are arrow-proof and the people feel quite secure once inside and the door closed. The door-frames are elaborately painted with some red pigment, but to say that any particular design is carried out would, I fear, be a stretch of imagination.

After half an hour with these people, we moved on, intending to make camp at the first water beyond the village. We were accompanied by a party of about fifteen natives. A few minutes after starting we came in sight of another village. Our friends shouted warning of our approach, and then took a tremendous delight in the scene of confusion and bustle which presented itself in the village.

Not wishing to make camp in or near a village, I chose a road bearing away to the right, and very shortly after came in sight of another village. There seemed no end to them. By now the district was fully alive to our presence. A most peculiar call, or war cry one might designate it, was constantly being given, and armed men were to be seen coming from all directions. The call consists of two notes, and resembles the croak of a frog. The first person to raise the alarm keeps repeating the one note until answered by a second person. These two then take up the call and keep it going, one on one note and one on the other. Every one within hearing takes up the call, and in almost no time the district is resounding to what sounds like the croaking of gigantic frogs.

During our journey downstream we came in touch with many large tribes of natives, all suspicious of us and ready to fight, but with only a few exceptions quite ready to be friendly when they realized that we meant them no harm and did not propose to remain long in their district. There were some tense moments, one in particular when we came unexpectedly on a village. We were seen just as we were about to ford a stream running past the village. In a very few seconds the bank was lined three deep with warriors, arrows fitted to bows and drawn to full length. Excitement was intense. Had one native even by accident let fly an arrow we should have been in a sorry plight, as immediately all would have let drive. They could not have failed to hit us, as the range was no more than 12 yards and they were on a high bank above us.

I had with me at the time three native police. Halting in mid-stream I endeavoured by signs to make them understand that our mission was a peaceful one, and then slowly worked my way forward. At last one of the natives, evidently a chief, slackened his tense attitude, took the arrow from his bow, and called out a string of words to the others. The effect was instantaneous. The line broke and a dance commenced, but after only a few steps the line reformed. This time, although each native had his full complement of weapons, no arrows were fitted to bows, and the shouts of defiance had changed to calls of welcome. Within a very few moments we were in the village, and by the time the balance of my party arrived friendly relations had been established.

When we were ready to move on again, many of these natives accompanied us on the next stage of our journey, acting as guides. Similar occurrences were frequent; but always we managed to leave friends behind us. Never were we forced to fire a shot either in attack or self-defence.

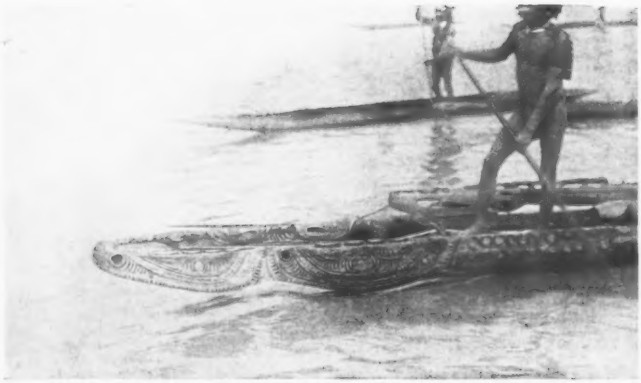
Among difficulties met with on the way were tributary streams flowing into the Sepik. Where these were too deep or swift-flowing to allow of fording by laden carriers, suspension bridges had to be constructed. Narrow gorges were found, the sheer walls of which rose hundreds and even thousands of feet above the river-level. Here it was a case of cut and hew a way to the summit, follow the ridge for a few hundred yards, then down to river-level again, and then almost immediately another ascent similar to the one just left behind: heart-breaking work and terribly slow progress.

In the worst of the country a very painful accident happened to my companion and assistant, which made an absolute cripple of him, and it became

Looking down the valley of the Sepik

Source of White river in face of Mount Tungom

Mount Mabiom round the base of which flows the Luap: Mount Sare in distance



Elaborate carving on Sepik river canoe: stone implements used

Head of the Bol river

First camp on headwaters of Sepik six miles below source

necessary to build a stretcher and have him carried: a most trying ordeal for the sufferer, which was borne with great fortitude and courage. Our pace was reduced by more than half, to 4 miles a day; and rations to a minimum, only two light meals a day being issued. Even so we had only five days' rations left and still 60 miles to go before getting clear of the mountains. Obstacle after obstacle obtruded itself, and time and again I nearly despaired of getting out. It was not until December 24 we won clear of the mountains and came out on a great plain. Here a new difficulty was encountered. Swamp after swamp was met with. Sometimes detours were made; on other occasions we cut a way straight through, working by compass.

It was impossible to commence rafting as yet, for two reasons: the stream was too swift, full of snags and rocks, with a series of rapids; and there was no timber at all suitable for raft-making. At last, on December 30, we found a timber which held out hopes of proving suitable. We also found a patch of sago palms. The river still flowed very swiftly at this point, but we decided to take the risk. From 30 December to 7 January 1928 we were busy raft building and sago making; but rafting was a failure, and a good deal of gear was lost.

By January 6 I had reached the decision that my raft-making was a futile venture. All the suitable timber available was cut, and from the lot we were able to make only six very poor rafts, quite insufficient to move the whole of my party. The river was still running very swift and studded with snags. The risk of upsets, smashed rafts, and loss of life, was far too great to warrant the attempt, particularly as I had found during the last few days that there were a number of non-swimmers in the party. With rafts only moderately laden there would be a fair chance, but overladen as we should be, it was out of the question.

Although we had delayed there eight days, the time was far from wasted. The carriers, who by then were very leg-weary and tired from constant travelling and carrying, had what practically amounted to a spell of at least comparatively light duty. They had full ration of sago and a good supply of pig and wallaby. Most of them showed an improvement in condition. Apart from the sago eaten daily, I was able to dry and bag about 400 lbs. for the road. As regards native rations, therefore, we were much better off now than a week before.

Our private supply, however, was running very low. One tin of meat, two tins of salmon, half a tin of concentrated soup, and three tins of tea, comprised the absolute total. An occasional pigeon or piece of pig helped out, but became tiresome when often repeated, and the flavour was never varied by sauces or seasoning. Flour was sadly missed, sago being only a very poor substitute.

Although it was hard to do so, we decided to move off by road on the morrow, leaving behind five of the six rafts. One, the best of the rafts, we would endeavour to take forward with us, very lightly laden. On January 7 Champion, with three A.Cs. and two carriers, made an attempt to work the raft, but with no success. One hundred yards below the starting-point the difficulties commenced. A side arm full of timber and snags flowed out from the river. Try as they would the crew were unable to keep the raft in the main

stream. They were swept into the side arm, missing the first snag by inches, touching the second, and hitting the third fair and square, end on. Large as the raft was, made of three 18-feet timbers each 2½ feet in diameter, the force of the water was such that the raft was thrown on end and then turned bottom side up. The crew quickly got clear, but Champion was not so fortunate. He was caught under the raft, and the pressure of water was so great that it was long before he was able to push himself clear. As he struck out for the surface, the rush and swirl of the stream again caught him and kept him under water. Not until 50 yards or more below the raft did he come to the surface, almost spent, and with just enough strength to struggle ashore. The whole party was safe, but by how narrow a margin! Such gear as had been taken aboard was lashed securely to the raft, and as this was now upside down in mid-river, there was absolutely no chance of recovery.

On January 14 we again began raft construction, and by January 18 we had seven rafts completed, and moved off with our party of forty-five. There were several very narrow escapes from accident, but all hands came through the day safely, having travelled about 30 miles.

Next morning, two hours after moving off, we came to the junction of the October and Sepik rivers, and found the Papuan Government vessel, the *Elevala*, awaiting us. The excitement of the meeting was indescribable. Tears of joy were shed by many of my carriers and several of the police. It was blessed relief to be once again aboard ship and relieved of further responsibility. I was thoroughly weary, and so tired of a constant diet of roast sago with an occasional piece of wild pig, cassowary, or wild pigeon, that I had arrived at the stage when I could hardly eat anything and was rapidly losing strength. My dominant thought after the excitement of the meeting had passed was a rest, unlimited food, and something sweet to eat and drink.

Our trip from here to the mouth of the Sepik (512 miles) was uneventful. On our way round the coast we called at Madang in the Mandated Territory of New Guinea, then at Samarai in Papua, and on January 30 reached Port Moresby, the point of our departure on September 17.

The Sepik may be described in four distinct sections from the head of the river to its mouth.

Section A, where it has cut its way through the mountains with a mean drop of 0·36 *in* 100 *feet.*

Except at narrows the river at low water forms rubble-strips of varying widths between the banks and the stream. Where and when it is in flood at high-water mark, the banks slope steeply into the river. Active erosion, both downwards and lateral, is proved by the washing down of material, landslides along the river slopes, and deep whirlpools at the river bends. In the rubble along the Sepik a metamorphic slate-like stone predominates. Diorite was also seen. Many gorges occur in this section of the river, through which the stream rushes at a terrific pace, creating a tremendous roar and thunder as it goes. The walls of these gorges are so sheer that one is compelled to turn back and seek a way above, climbs varying from a few hundred to 2000 feet.

Section B, a comparatively straight course with many arms running over gravel beds.

This section may be divided into two parts, the first of which begins at the junction of the Hoffnungs river with the Sepik and finishes at a point named the "Mountain Gate." Throughout this stretch the mountains gradually draw farther and farther away from the river and many stretches of level forest country occur. Pigeon, cassowary, and wallaby abound here. The mean fall in the river is 0·34 in 100 feet.

At the Mountain Gate the river breaks its way through a low barrier and pours down a step 5 to 6 feet high. Above and below the Mountain Gate the trees are laid waste far and wide. For 5 miles the drowned forest with its naked trunks flanks the river. Young growths dress the floor of this dead forest with a scanty covering of green. The second division extends downstream from the Mountain Gate to a point 8 miles below the junction of the Holländer River with the Sepik, just over the border in Dutch New Guinea, the mean fall being 0·17 in 100 feet.

During this stretch the river is studded with small islands, and broken into many side arms, gradually losing its force and speed. Many sago swamps alternate with a young forest growth heavily interwoven with vines and creepers flanking the river on both banks.

Section C, from the end of Section B to a point 250 miles farther downstream.

The fall over the whole of this distance is approximately 180 feet. For the first 30 to 40 miles the river is swift flowing and has numerous rapids, with a very winding course. Floating timber forms many an obstacle to progress and adds greatly to the difficulty of navigating unwieldy rafts. At sharp bends the timber frequently forms barricades 6 and 8 feet high. The timber changes in character, being mainly old forest as on the Fly River, with sections of young forest on the convex shore of the river. Bananas and coconut palms appear on the upper stretch of this section, gradually showing up in larger numbers as one progresses downstream.

Section D, from C to the mouth of the river.

In the whole of this distance, about 300 miles, the fall is 26 feet. For a distance of 110 miles the forest country keeps close to the river, then slowly runs back from the stream and at about 130 miles from the end of section C the forest is replaced by immense grass plains. Where the forest has been killed off by flood waters, rattan grows well; palms, bamboo, and rushes are also seen. The large grass plains stretch for 50 to 60 miles downstream. Below this are further plains of grass mixed with bulrush. These plains often extend away on both sides of the river farther than the eye can see from masthead. Many lagoons alive with duck are dotted about this district.

After these plains there is more forest country. Here flood waters play an important part. In sections the virgin forest has been quite killed off; and a new growth of sago, Kentia Palm, and Pandanus takes its place. For some 35 miles from the mouth of the river and on both sides of the stream, a light stunted timber grows. Behind this and merging into the virgin forest still farther back is a mangrove-like spruce. All about the mouth of the river and for some 5 or 6 miles upstream Casuarina are to be seen.

Unlike the Fly River, with its immensely wide estuary and shallow waters, the mouth of the Sepik is narrow, about a mile wide, and very deep. Tidal bores do not occur on the Sepik.

On an expedition such as that just described, little time was available for the collection of geographical, geological, or anthropological data.

With distances, conditions, and food resources unknown, our main consideration was speedy progress; everything else had to be sacrificed. To explore either river, the Sepik or the Fly, would be comparatively easy, but to cross the main range dividing one from the other was a hazardous undertaking owing to the transport problems and difficulties.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: All the Fellows of this Society, *ex officio*, know that New Guinea was discovered by the Portuguese a little over four hundred years ago, and one would say that some four hundred years was a sufficient space of time in which to discover and map the interior of the island, and to know something about it. Actually, for something like 350 years nothing was known of the interior. We have, of course, the outline of the coast laid down, bit by bit, by great navigators such as Tasman, Torres, Dampier, and Captain James Cook, whose bicentenary we celebrated on the occasion of our last evening meeting. But the interior was left severely alone. The reason for that appears to have been, first of all, that the climate is very bad; secondly, that there are a great many physical difficulties; and thirdly, as was said by the late General Rawling, who was killed in the war, that the natives had, apparently, a just reputation for treachery, ferocity, and cannibalism. Those three qualities are not likely to attract single explorers, though they might be ignored by those who explore in large and well-found expeditions.

In 1884 a change took place. New Guinea was divided up. The western part, that is to say west of 141°, became Dutch; the eastern part was divided between Great Britain and Germany. Since the war Australia has not only had possession of Papua but also administers the Mandated Territory to the north. So that, roughly, New Guinea is divided into two equal portions: Dutch to the west, and Australian to the east.

We have had several lectures on New Guinea, but most of those, two in particular, dealt with Dutch New Guinea. Mr. Wollaston, who is going to read the paper to-night, was a member of the expedition which left England in October 1909 and spent some eighteen months in New Guinea in the region of the Mimika river. He commanded an expedition in 1912–13, also in Dutch New Guinea. And so it is very appropriate that he should read the paper to-night because, unfortunately, Mr. Karius, the author, is unable to be here. Mr. Karius is a District Commissioner in Papua, who took advantage of his office in a way which we hope all administrators will do. He made a great journey, and has done what no other explorer has done, namely, traversed the main watershed and come out on the other side.

Mr. Wollaston then read part of the paper printed above, and a discussion followed.

Mr. V. C. DUFFY (Acting Secretary to the High Commissioner for Australia): I think I should preface my remarks by saying that Sir Granville Ryrie, the High Commissioner for Australia, was very disappointed at not being able to be here this evening, but in absenting himself he is obeying doctors' orders. Sir Hubert Murray, the Lieutenant-Governor of Papua, who is now in London, was also unable to come because he too is ill. At the conclusion of his lecture Mr. Wollaston referred to the fact that Mr. Karius is an official of the Government Service in Papua. The journey, a description of which we have all listened to with great interest, was undertaken by him and another official of the Government Service, and I think it is commendable when officials of Government

administrations in the outposts of Empire take opportunities, consistent with time and the nature of their duty, of pushing inward from their respective bases and gaining additional knowledge of the areas in the administration of which they form part. How well Mr. Karius and Mr. Champion performed their task is clear from the paper to which we have listened, notwithstanding its modest tone.

I have not visited New Guinea, and I must therefore rely for my knowledge of this particular expedition on what I have read and what I have listened to to-night. It is quite clear from that, however, that Mr. Karius and his companion made a journey across the widest part of New Guinea, which, as the crow flies, is some 500 miles—I speak subject to correction—but which was trebled owing to the deviations necessitated by the nature of the country traversed. They made that journey in good time in spite of the fact that they had scanty resources; they had to carry their food because they could not rely upon finding natural products of the soil which sustained life; and, for carriage, they had to rely on natives, as animal transport apparently was out of the question in that particular territory. Another feature of their journey was that they made friends with the natives they encountered on the way. And these natives—again I speak subject to correction—had not previously seen a white man. I think it can be said unboastfully that their feat has won and will retain an honourable place in the history of geographical exploration.

Dr. HADDON: I have great pleasure in adding my congratulations to Messrs. Karius and Champion on the very remarkable exploration they have made.

The work of magistrates and patrol officers in Papua is very arduous, as can be recognized if the Annual Reports of the Territory of Papua are read through with discernment, for these give only bare records of what is expected of, and always done by, the officers and native constabulary. New Guinea owes a great deal to the native constabulary; they are resourceful, loyal, and extremely useful men. These trained officers are always ready for any emergency, and it was to two of such that the speciously simple instruction was given, "To ascertain the source of the Fly River, and to find a pass across into the Mandated Territory." In 1926 an elaborate expedition was projected in Oxford to go by boat as far as possible up the Sepik, cross the divide, and return by the Fly River; but it fell through as the large sum of money that was required could not be raised, and it is doubtful if the expedition as planned could have been successful; at all events, it was a hazardous project. Messrs. Karius and Champion have traversed this route in the reverse direction without any assistance from the outside or any elaborate preparation, with a few native police and thirty-six carriers. It would be interesting to know what the cost has been; probably less than a tithe of the estimated cost of the proposed expedition.

The two expeditions of Messrs. Karius and Champion had a geographical objective, and they had to be rapid on account of commissariat difficulties, so it would be unreasonable to expect that much ethnographical information could be obtained, especially as most of the country is uninhabited and the rest but thinly populated. On the first expedition a certain amount of general information about the natives was obtained by Mr. Champion (Territory of Papua, Annual Report, 1926–27 (1928), Appendix B) at the Bolivip villages of the Unkia, a people who live at the headwaters of the Palmer and Fly rivers. The men are not tall, though some reach 5 feet 7 inches in height; many are very muscular; they are rather light in colour, especially the children; the black woolly hair is often plaited in pigtails; the nostrils are perforated and carry ornaments; they wear a penis-gourd; they use a stone adze; they smoke native tobacco as cigars or cigarettes in a small bamboo tube about 6 inches long; their arms consist of bow, arrows, and stone-headed clubs. The women wear a short grass petticoat

and do not wear ornaments. The houses are about 9 [illegible]et square on short piles; the walls and floor are made of split planks and lined inside with sheets of bark, and there is a central, square, sunk fireplace. Every village has at least one men's house of larger size. There are large fenced taro gardens, which are kept clean and free from weeds; apparently, the sweet potato has only recently been introduced. They keep pigs and a small miserable yellowish-brown dog. It is significant that the women showed no fear of strangers, and this in spite [illegible] the fact that they had never seen a white man. Mr. Champion concludes by saying, "They are the most hospitable and friendly natives that I have met."

Mr. Leo Austen, another of these very plucky Government officials, has made some interesting investigations of the Tedi, or Alice river, peoples, and we have a little information about the peoples of the upper Fly and Palmer rivers; though unfortunately we are quite ignorant about the social life, ceremonies, and beliefs of all these tribes. The little that we do know about these folk does not afford any clue as to the origin of the coastal cultures. I have hazarded the conjecture that the latter came originally from the Sepik and found their way to the south coast of New Guinea, but so far as the work of these Government officers is concerned, it seems to me fairly certain that these cultures did not come down the Tedi (Alice), the Feneng (Fly) or Bol, or the Luap (Palmer) rivers. It would seem that their southerly drift took place much farther east, at all events one or more movements took place down the Strickland.

There can be little doubt that the same general material culture extends from the Nassau mountains of Netherlands New Guinea—for example, that of the mountain pygmies described by Mr. Wollaston—along the north and south flanks of the main range and gradually disappears in the eastern part of New Guinea. Examples of peoples having this culture were found by Mr. Leo Austen in the Star mountains, and Messrs. Karius and Champion have also found it in the mountains whence the Palmer river rises. There is also evidence that cultural influences have passed from the north across the Victor Emanuel range into the district watered by the Tedi and upper Fly. There are many unsolved problems, and it is only by opening up a country in this way that we shall be able to solve them; the most promising field in this respect is the central region between 142° and 144° E. long.

These Government officers are extremely modest, but they do work of which not only the Empire but, I may say, especially Australia, may be proud because, I believe, all of them are Australians. Mr Champion, of whom we have heard so much this evening, was actually born in New Guinea, so in him we have a handsel of native New Guinea white people opening up their own country.

Finally, I would like to express, on behalf of all students, the gratitude we feel to Sir Hubert Murray, Lieutenant-Governor of Papua, for encouraging such explorations as have been described to us this evening and for the warm support he has always given to the study of Papuan ethnology.

The PRESIDENT: The hour is late, and I think you will all agree with me that we have listened to the account of a remarkable bit of exploration. We shall all agree with Dr. Haddon and Mr. Duffy when they say that it is very much to the interest of the Empire that the officials of the Government in a place such as New Guinea should take the trouble to explore, as Mr. Karius and Mr. Champion have done. We are very much indebted to those who encourage them to do so, and we congratulate Mr. Karius, in his absence, on his excellent feat; perhaps, as Mr. Wollaston says, the greatest feat that has been accomplished in New Guinea. We also thank Mr. Wollaston for the trouble he has taken in reading the paper and illustrating it for us.

THE SAURA AND SAHARAN OASES; AND THE NIGER FROM TIMBUKTU TO JEBBA: *A paper read at the Evening Meeting of the Society, 10 June 1929, by*

LEONARD T. SCOTT

MY paper this evening deals principally with the beginning and end of a journey made in 1927–28 across Africa from the Mediterranean to the Gulf of Guinea; but to give continuity to the account I have inserted brief outlines of the intermediate stages in their order. It may not be out of place, also, to relate some of the circumstances in which the journey was made, and the object in making it.

In the first instance, I conceived the idea of crossing the Sahara to Timbuktu upon my return to Europe from a very short visit to Morocco in 1925. I proposed to make the trip alone, and I had no special scientific object in mind, for apart from my limited knowledge of surveying, the French have left little scope in this sphere along the route I intended to travel. In fact, during the second half of the desert journey my small convoy followed hard on the heels of the elaborate Draper Mission. Therefore, I had decided to confine myself to a general study of the country and the people. The first step was to obtain the permission of the Governments in Paris and Algiers to make the journey, and this I succeeded in doing with the kind assistance of the Government of Northern Ireland, the British Embassy in Paris, and my friend Mr. V. C. Scott O'Connor. I am greatly indebted for that permission, and also for the generous facilities which accompanied it, and which contributed so much to the success of the expedition.

I entered the desert at Colomb Bechar, having arrived there by rail from Algiers. When arranging my itinerary during the months of study and preparation before leaving England, I included the Saura and Saharan oases because, so far as I could ascertain, they had been neglected by other British travellers. At Colomb Bechar I had the good fortune to make the acquaintance of Lieutenant Athenour, who had seen sixteen years' service in various Saharan posts, and who was my companion as far as Timimun.

We left Bechar on October 1. The railhead lies midway between the courses of the Zusfana and the Gir, the wadis whose confluence at Igli forms the Saura. Travelling via the wells of Gherasa and Menuarar, we arrived at Jebel Arlal on the second day; but waited until nightfall before penetrating these mountains, as the pass of Megisem el Habba is a favourite place for ambush by raiders from Tafilelt. We entered the Zusfana at the valley of Taghit or Tar't, which contains five villages, the home of the Beni Gumi, formerly a very powerful tribe. The bed of the wadi was covered with mimosa and tamarisk trees, and tufts of drinn, which is a fine silken grass. It was dry, as water only flows there during the infrequent rainstorms, but the black rocks on the surface had been polished by ablation until they shone like burnished metal.

The course of the Zusfana is well defined at Taghit, and near Bu Ruis the wall of broken rock which forms its right bank is covered in several places with drawings of moufflon, gazelle, ostrich, rabbit, and elephant, most of which are clear and good. It is a matter for speculation whether all these

Fig. 1. Mr. Scott's route across the Sahara to the Niger

animals ever inhabited this region or the figures were executed by people who had seen the originals elsewhere. At any rate the only wild animal I saw in the neighbourhood was the rabbit. Towards Igli the wadi becomes less definite, owing to invasions of sand, and is only traceable by its vegetation.

The Saura is really a narrow valley, which penetrates into the heart of the desert to where the Tuat oases end on the threshold of the Tanezruft and the dunes of the Erg Shesh. It runs round the base of the Great Western Dunes to Ksabi, where it disappears for a space and comes to light again under the name of Mesa'ud, though this title is a vague one. Like the Zusfana and the Gir, water rarely flows in it; but the presence of the vital element in abundance beneath the surface is evidenced by the almost unbroken chain of oases which it sustains. The right bank is composed of grim hills of black stone, and cliffs of sandstone and clay. Beyond this bank a chaotic world of hamada or broken rock apparently stretches to infinity. The left bank is mostly argillaceous, and, as far as Ksabi, is continually menaced by the Great Dunes, which tower above it. The first oasis of extent is Beni 'Abbas, which we reached after a day's ride from Igli. The palm gardens, containing some 8000 trees, lie between two cliffs. The village is dominated on the left by a large fortress, behind which the dunes rise to a height of several hundred feet.

Irrigation in the Saura is facilitated by innumerable wells. At the side of the wide mouth of each well stand three mud columns, across the top of which two short bars are laid to bridge the spaces between them. Each bar acts as a fulcrum for a lever of wood, weighted at one end with a huge stone. Big timber is scarce, so that the 25-feet levers are usually constructed of short lengths tied together with rope. A rude platform over the well supports the two workers. Each pulls on the rope attached to the top of his lever, until the vessel of plaited fibre below him is submerged in the water. The rope is then released, and the water is drawn to the top, where it is emptied into a hollowed palm trunk, stretching across the well, which in turn delivers it to numerous small canals running through the gardens. A continuous flow is maintained by working the levers alternately.

The dunes have invaded the Saura at Tamtert, and the oasis lies in the trough of two immense waves of sand. Why it has not been obliterated long since is known only to Providence. From there the villages are so close together that their suburbs of palms meet and unite. It is impossible to say where one begins or ends. Millions of flies, attracted by the filth and dates, make life a burden until one becomes used to them. They are similar in form to the ordinary house-fly, but much smaller and maddeningly persistent in their attentions. Resistance is almost futile, as dislodgment from one part of the body only means descent on another part. The flies cause food to be bolted in undignified haste at mealtimes, and the siesta is only possible under a net. They are also the cause of widespread ophthalmia.

The subject of the different races and social classes in the Saura, and the Saharan oases farther south, is of a too controversial nature to be touched on more than lightly here. The predominating races are Arabs and Berbers, who are divided into two classes, Shorfa and Merabtin. The Shorfa are the direct descendants of Muhammad, and therefore the more influential. The Merabtin include those more distantly related to the Prophet. A. G. P. Martin in his

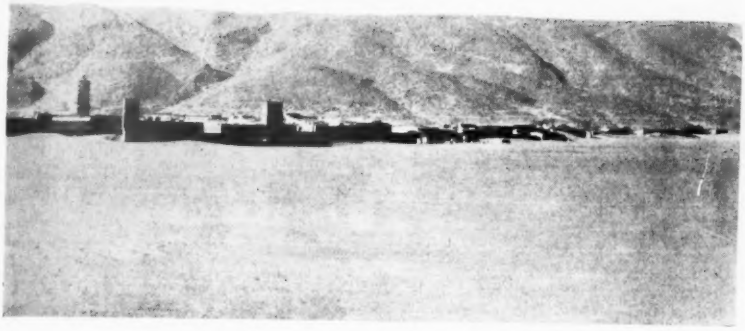
book 'Les Oasis Sahariennes,' gives another class called Roturiers, which is lower than the two I have mentioned. In addition, we have the Mehajeriya, the Islamized descendants of the Jews, who once controlled the oases. Almost all the manual labour is performed by the remaining people or class, whose removal would mean the extinction of the other races. There has always been some confusion regarding a precise description of these Haratin. Broadly speaking they are the freed descendants of negroes brought as slaves from the Sudan. A Hartani is free to leave his master if ill-treated, yet he is a slave to this extent that in many cases he receives little beyond food and clothing as remuneration for his labour.

There is a marked difference in the social systems of the two races. The Arab is an autocrat, and the Berber is a violent democrat, extremely jealous of his social liberties. The Berber is a wild, tumultuous fellow of open countenance, who usually makes a staunch friend. The Arab, on the contrary, is often a surly, crafty individual, who is not to be trusted. These two peoples have always been enemies, but by strong and tactful government in the Sahara, the French have suppressed open rivalry, and the two races give expression to their animosity in stories to one another's discomfiture.

The power behind the Berber is the Jema', which is a council elected by the different factions or villages. It is this council which chooses or opposes the Qaid, and all questions of administration are considered by it. The Jema' has supreme control. A very different state of affairs exists in the Arab villages. There, the lord of the Qasba—a great rectangular citadel which occupies the centre of every village—is the sole ruler. He and his family alone tenant this building, which among the Berbers is used as a common store and a place of refuge in case of attack. Where the Arab Qaid is also the head of a zwaia his rule is absolute. No one dares to impugn his decisions on matters civil or criminal. A. G. P. Martin gives the following interesting cycle of life for the populace in the oases: children, up to 12 years; fasters, from 13 to 18 years; young men, from 19 to 28 years; men of mature age, from 29 to 45 years; and old men, from 45 years upwards.

Gerzim and Kerzaz, two of the most important oases of the Saura, have rival zwaias. Gerzim claims to be older and more venerable than Kerzaz, but the overwhelming attacks of flies discouraged a close examination of its history, and we left it hurriedly in the afternoon. The dipteral population pursued us, and descending surreptitiously upon our backs and beasts, in this way migrated to Kerzaz, where we arrived the following morning. The Saura narrows considerably at Kerzaz, and the village overflows from its low plateau beneath the Western Dunes towards the opposite barren wall of the wadi. The striking feature of Kerzaz is the tall, slim minaret of sandstone flags, which rises out of the centre of the village. In a country of mud buildings this construction *de luxe* may be taken as proof that the Order of Kerzaz is more important than that of Gerzim.

From Kerzaz we rode among low sand-hills, crowned with gnarled tamarisks, to Timudi, where the old village is perched on the top of a naked cliff. It looked a queer place, something that might have existed in the Neolithic Age. The Saura makes a detour at Timudi, so we left it, and crossing the hamada, re-entered the wadi near Ksabi, where it sweeps round in a



Kerzaz oasis in the Saura

Native cemetery at Timimun, Gurara oases

A corner of Timbuktu

Tamentit, former Jewish stronghold near Adrar in the Tuat oases

magnificent palm-lined semicircle. Stretches of short, rich grass enclosed pools of stagnant water, in which frogs and mosquitoes flourished.

After Ksabi our route lay eastwards along the foot of the Western Dunes towards the first group of the Saharan oases, and we definitely parted company with the great wadi, which continues its south-easterly direction. We crossed alternate stretches of nebka—small white dunes—and dark reg to Hasi 'Abdul 'Adhim and Hasi el Amira. The word "Hasi" indicates a well which is covered by a dome of stone to prevent it becoming silted up with sand. A narrow opening on one side of the dome allows the water to be drawn from the well. It often happens, when the water is low, that one or two men have to crawl through the hole in order to pass the precious liquid to the surface. The wisdom of this cover is evident at El Amira, which is surrounded by dunes, and would be destroyed in a short time if left unprotected.

From Taghit to Hasi el Amira, the Western Dunes had been our constant companions, but up to the present we had been content to view them from below, and evade the moment of closer acquaintanceship by following the line of least resistance. After El Amira, however, further evasion was made impossible by three vast ranges that lay directly in our path. The moon had risen and was shining brightly when we reached the base of the first range. The slope before us rose at an angle of 75°; but a little farther along we found a less dangerous acclivity and began the ascent. With care the crossing of these dunes on a horse that has been trained for the work presents little danger; but it is a perilous undertaking on camel-back. Baggage camels are the greatest difficulty and require careful handling if they are to make the crossing in safety. When we were only a short way up the incline, a badly tied load slipped over the tail of one of the animals, which floundered about, roaring and kicking with terror. The feet of man and beast alike sank deeply in the soft sand, and frequent halts were necessary for rest. At length we reached the hard blade-like summit, and found ourselves in the midst of a confusing multitude of curved crests. In these mountains of sand the rugged grandeur of rock was absent, for the wind, as it fashioned each one, seemed to have striven to excel the last in grace of symmetry. Some confusion was caused in traversing the second range, when a baggage animal overbalanced and tumbled into the hollow between two dunes. Fortunately the brute was uninjured, but its load was scattered in all directions.

The fertility of the Saura had given place to a depressing sterility. Until we reached Timimun, the oases of Sharwin, Beni Islam, and Beni M'lluk were the only hospitable spots in a region of hills of broken sandstone and black shale. Once we paused on the brink of a precipice, heaped with slabs of slate, and looked down into a broad valley, where fire had blackened everything, and sand was slowly covering the charred remains.

The Saharan Oases are in three main groups, called Gurara, Tuat and Tidikelt, of which the chief villages are Timimun, Timi or Adrar, and In Salah respectively. We arrived at Timimun on October 18. The striking feature of its situation is the vast depression on the rim of which the village stands. This sebkha of Gurara, as the depression is called, has the appearance of a dried-up lake, and when rain falls a thick layer of pure salt rises to the surface of it, and is gathered by the villagers for domestic use. There are

many other similar depressions of less extent throughout the oases, and the most important of these is the sebkha of Tuat. The beds of some sebkhas are covered with a coat of mud, which the heat of the sun causes to break into crisp flakes.

Timimun is like all other Saharan villages, in it everything sleeps and everything crumbles. Two thunderstorms occurred when I was there, and it rained spasmodically for a fortnight, with the result that the walls and roofs of the houses were scarred and pitted as though by gunfire. The streets are intersected by lines of aqueducts, for here, as in the other Saharan oases, a constant flow of water for irrigation and domestic use is secured by methods very different from those employed in the Saura. Wells are, of course, the source of supply; but the continual manual labour involved in drawing the water by levers is non-existent. This is due to the fact that a series of underground channels or foggaras connect wells sunk at intervals and tapping different levels of water. These channels carry the water to distribution centres, which are circular basins, where comb-shaped sandstone dams deliver it to the irrigating canals. The water so provided is the property of all those who contributed by their labour or money to the construction of the wells and channels. A register of the changes in the personnel of the proprietors is kept by the committee which superintends the functioning of the system. Those who are not proprietors pay for the use of the water, the supply being controlled at the dams in the distribution centres. A well lasts about thirty years. Numerous small fish live in these irrigating channels.

As elsewhere in the French Sahara, the administration of the oases is in the hands of the military, and all civil matters are dealt with by the *Bureau Arabe* in each post. Each of the three principal centres has an infirmary with an efficient European medical man in charge, but the best work of these officers is done when they are on tour, as it is difficult to induce the natives to stay in hospital. Schools are also provided at which the attendance is good, and the work of the pupils is of a remarkably high standard.

I passed a month in Timimun waiting for some baggage to arrive from Bechar, and on November 14 left for In Salah. There are two routes from Timimun to In Salah. One is an almost direct line between these places, but runs across the desolate region which surrounds the barren Tadmait plateau. The other route, which I travelled, is easier and more interesting as it leads through the remaining Tuat and Tidikelt oases.

We camped on the first night at Taursit, where the gardens have been invaded by dunes, and to arrest their progress a frail fence of plaited palm-leaf has been erected round the oasis. This barrier shields the trees from the wind, which deposits its burden of sand against it. Each year the height of the protecting hedge is increased as the dunes creep higher, and time alone will disclose the result of the duel between man and the elements.

We did not travel far from Taursit on the second day, as shortly after our departure one of the camels took a violent dislike to his load. His frantic efforts to rid himself of it succeeded so often that I sent him back to Timimun with one of the escort to be replaced by another more tractable. The rest of us waited at the neighbouring oasis of Ughda. This oasis is spread over the side of a ridge which ends in a qara. Qaras, or qur, are isolated, flat-topped

hillocks of eroded sandstone, and are a peculiar feature of the landscape in the oases. The sides of the qur are generally covered with rounded lumps of hard stone, about twice the size of a golf-ball. These have been exposed when the softer material in which they were imbedded was consumed by erosion. The one at Ughda had a few lines of Tifinar, the script of the Tuareg, scratched on a clear space above the crude drawing of a camel.

A few days after leaving Ughda we reached Sba, which is the southern limit of the Gurara oases, and crossed 27 miles of naked country, in a mild sandstorm, to Adrar. Adrar is the name of the fort and commercial village which rose beside Timi when the French occupied the Tuat. The fort is much smaller than the one in Timimun, and is completely enclosed by a wide moat, so a drawbridge is lowered during the day to provide communication with the outside world. Timi and a group of thirteen other villages are spread out behind the fort. A number of Tuareg were in Adrar when I was there, with flocks of sheep and goats, which they had driven north to barter for tea and sugar, cloth, and the coloured woollen covers woven by the women of the villages. Until these people come north in the months of November and December practically the only fresh meat obtainable is from camels grown too old for work.

Of the three groups of the Saharan oases the Tuat is the most historical, for as early as the third century the Jews reached and established themselves in it. A further immigration in the sixteenth century greatly strengthened their position, and, their influence spreading to the other groups, a new Palestine was formed. The Jewish rule and religion was widespread in spite of an increasing Arab population, and peace prevailed between the two races. At the end of the fifteenth century, however, the Arabs had become very powerful, and the expulsion of the Moors from Spain was taken as an excuse for the overthrow and massacre of the Jews. Traces of this Jewish occupation are still to be seen, and their citadel of Tamentit, near Adrar, is one of the most curious places in the Sahara. Approaching it from Adrar, one crosses a sebkha, and then passing through the gardens, the village is entered by a cleft in the mass of rock upon which the houses are built. The streets have been cut through the rock, and they are too narrow and tortuous to allow a loaded camel to pass freely. Some of the interior walls are built of salt, and the centre is a huge Qasba surrounded by a moat. The place is divided into quarters, which are shut off by heavy studded doors. To-day the old moats are silted up with sand and women come to weep in the ruins with the hope that their tears may be rewarded by a revelation of hidden treasure.

Tamentit until lately possessed another feature of interest. This was a large aerolite, which lay in a secluded corner at the mouth of an underground passage. The stone had been there so long that it had become an object of veneration by the present inhabitants, who repulsed all advances of the French to have it removed to a place where its true value would be appreciated. But after protracted negotiations, the scruples of the Islamized descendants of the old populace were overcome by the sum of 30,000 francs, and the aerolite was removed to France.

As we advanced southwards from Adrar, the oases of Tuat increased in number. Locusts are the cause of considerable damage to the meagre crops

of wheat and barley cultivated by the natives, who retaliate by eating the insect. It is usual to see women sitting motionless and alone outside the villages. Beside each there is a basket, and the sand, a short distance away, is dotted with stones set on end. Small hollows before the stones contain handfuls of green stuff. These are the locust-traps. At intervals the women come to life, and going round, creep up behind each stone in turn. With a swift push it is knocked over on top of the decoy and any insects which may be devouring it at the time. The children and the more energetic of the adults pursue the locust with an affair similar to our butterfly net.

The danger which threatens Taursit has almost reached the point of disaster in some of the oases of the Tuat. The sebkha, which rivals that of Gurara, opens out at El Ahmar, reaches its broadest point at Bu 'Ali, and ends at Sali, where the lower course of the Saura or Mesa'ud comes to view once more. The Tuat ends in a final burst of fertility at Reggan, where La Compagnie Transsaharienne has built a fine hotel and base for their motor cars, which run from there down the meridian of Greenwich to the Niger, a distance of about 1200 kilometres.

The last group of the oases, the Tidikelt, lies to the east of the Tuat, from which it is separated by an absolute wilderness of rock and sand. It is a distance of 92 kilometres from Reggan to Aulef, the first oasis of Tidikelt, and there is only one reliable water-hole. The Tidikelt differs little from the other groups, except for a number of artesian wells at Tit and In Salah, which throw out great volumes of tepid water.

When I left In Salah I had unofficial charge of a French supply convoy for the isolated post of Tamanraset, in the Ahaggar Mountains. This responsibility proved more of a curse than a blessing, for we had the greatest difficulty in traversing the wild ranges of the Muidir, and the still wilder and higher Ahaggar. The jagged slopes cut and bruised the soft padded feet of our beasts, of which several died or were so disabled as to be unfit for work. The progress also on many days was depressingly slow. As the culmination of twenty-five days' hard labour we were washed out during a rainstorm the night before our arrival at Tamanraset. Our animals bolted at sight of the torrent, and I reached Tamanraset on foot in a rather unkempt condition. I was hospitably received by the small company of Europeans there, in spite of the fact that they were on short rations, and were greatly disappointed to hear that the supplies I had brought them only consisted of petrol and ammunition.

After seventeen days at Tamanraset I left with three Tuareg as companions, and crossing the end of the Tanezruft to the Adrar of the Ifoghas, reached the Niger at Burem, by way of Kidal, one evening towards the end of February 1928. The sight of so much water stained with green, where islands of grass and reeds broke through the surface, was all the more impressive after the five months spent in the sterility of the Sahara. A short time afterwards I arrived in Timbuktu, and made many inquiries about conditions along the river between that city and the Nigerian frontier. But once the course of the Niger passed outside the Sudan Colony all the information I could obtain was vague and unsatisfactory. Indeed, mention of such names as Sai and Gaya caused native informers to exhaust their powers of explanation in trying to convey to me the enormous distance to these places.

Kabara, the port of Timbuktu

Cargo barge on the Niger, French Sudan

Gao, French Sudan

Labazenga rapids, Niger river

The Niger from the Governor's Palace, Niamei

I finally decided to see for myself what lay beyond, and towards the end of April, after a month in Timbuktu, I embarked in a canoe and voyaged down this least-known section of the great river to Jebba, about 1300 miles away. An account of present conditions below Timbuktu may be of interest.

The famous city of Timbuktu lies about 10 miles north of the western buckle of the Niger, where the straggling growth nourished by the river disappears in the sands of the great desert. The ruinous condition of the houses on its outskirts is somewhat counterbalanced by the well-preserved buildings in the centre of the town; but despite all the efforts of the French to revive it, Timbuktu is slowly dying. It has shrunk to a mere skeleton of its former greatness, and to-day is not more than a mile in circumference. This shrinkage has taken place for the most part on the side next the river, and in confirmation I was shown the foundations of the old central citadel, which have been discovered beneath a thick mantle of sand, outside the present southern limits of the town. Scarcity of building material has hastened the demolition of vacant houses in order to provide for the repair and construction of others. An instance of this occurred a few years ago, when a whole section of the town was pulled down to be used in the construction of an hotel for the Citroën Motor Company, only to be abandoned later.

Timbuktu produces nothing, and exists solely by its trade, in which 75 per cent. of the population is engaged. Native salt is the basis of the market, and therefore the Azalai, the great caravan which goes north into the wilderness of Juf each autumn to bring the salt from Taudeni, may be taken as an accurate barometer of the prosperity of the town. In 1927 only two thousand camels took part, a mere fraction of the twenty thousand which composed the caravan during the best days of the Songhai Empire. The resident population at present does not exceed three thousand, and is gradually decreasing owing to the increased wealth which cotton-growing has brought to Dire, farther up the river. Several large French trading companies have stores in the town; but the pendulum of prosperity seems to swing more and more in the favour of its old rival, Gao, 300 miles down-river. In consequence, one of the most important houses intends to reduce its activities at Timbuktu, in order to take advantage of improving conditions farther east.

A shallow canal, which winds up from Kabara to Timbuktu, is used for the transport of merchandize between the port and the capital when the Niger is in flood; but it is indirectly the cause of an annual paralysis of affairs in Timbuktu. This is an epidemic of guinea-worm, which breaks out among the natives each year, through drinking the unfiltered water of the canal. The disease is more painful than mortal, but when I was there quite 40 per cent. of the inhabitants was temporarily disabled by it. The water supply for Europeans, although drawn from wells, is carefully filtered under the supervision of a medical officer. The vegetable gardens all lie close to this canal, from which the water is drawn into large ponds for irrigation. The stagnant water has not been allowed to become a breeding-ground for mosquitoes, so that little annoyance is experienced from these pests, which make nights spent on the Niger a misery.

Although Timbuktu is still a stronghold of Muhammadanism, there is a school for girls as well as one for boys, and from these pupils qualify by

examination for entrance to the High School at Bamako. A further examination at Bamako carries the most promising to the University in Dakar.

Exactly a month after my arrival in Timbuktu, I received word that a canoe was ready for me at Kabara, and I rode down there, my baggage being conveyed on donkeys. The direct line of communication between the two places is a broad, sandy track, crossed at two points by the canal. There are no

Fig. 2. Sketch-map to illustrate Mr. Scott's journey down the Niger from Timbuktu to Jebba

bridges, and those who are not mounted undress and wade across or wait the passing of a canoe.

Kabara only deserves the appellation of "port" during certain months of the year, when the water in the great river is high. The rest of the year one has to descend to the Niger itself in order to embark. The harbour is a circle of sand-bound water at the head of a canal, which runs up from the Niger. Navigation on the river in the eastern half of the Sudan Colony is controlled by a native at Kabara, who, locally, seems to be a law unto himself. He is outside the jurisdiction of the Administration in Timbuktu, and only takes orders from Kulikoro, 500 miles away. The dwindling prosperity of the desert city

has been a setback to the expansion of Kabara, but not so much through a decrease in its activities as a port as by a reduced market for the calabashes, pottery, and garden produce of the inhabitants. A powerful wireless station outside the village keeps the Administration at Timbuktu in constant touch with the isolated posts in the desert to the north. There is also a large aerodrome, but the hangars are in use only when machines come from Bamako.

From Kabara to the Nigerian frontier, following the course of the Niger, is roughly 1000 miles. Of this, 400 miles of the river lie in the Sudan Colony, and the remainder forms the boundary between the Niger Colony on the left, and the colonies of Upper Volta and Dahomey on the right bank. This section of the Sudan Colony forms the least developed portion of the Niger. For 250 miles from Kabara the river is in continual conflict with the desert, which each year increases the strangling embrace of its wind-borne sand. The Niger remains broad and majestic in spite of the onslaughts of the desert; but its banks, where elevated beyond reach of the inundations, are barren except for dwarf-palms and straggling thorn bushes. In many places the waters of the river wash the feet of great dunes which have risen on either side of it. Roads are non-existent, and it is only recently that a proper motor route was opened between Timbuktu and the cities farther west. Therefore, all traffic is water-borne. Mails, merchandize, and travellers all follow the winding course of the Niger. Any beneficial results derived from this form of transport are overcome by its slowness. For almost six months of the year, when the Niger is low, the ancient stern-wheelers, employed by the Government in towing cargo and passenger barges, are out of commission owing to rocks and sand-banks in the river. During these months the barges passing up and down the Niger have to be poled or paddled by native crews, and it takes a barge, poled by seventeen men, three months to reach the railhead at Kulikoro from Ansongo, near the eastern limit of the colony. Mails, however, do not suffer the same delay as they are conveyed in special steel canoes, each propelled by a crew of twelve, and which, by a system of relays, travel both night and day.

The inhabitants of the villages, which dot both banks of the river, are extremely poor, and their numbers are reduced by frequent epidemics and child-mortality. The only advantage taken of the natural irrigation provided by the annual inundations of the Niger is the planting of rice and millet sufficient for their own needs. When the waters begin to subside, large areas are enclosed in such a manner as to trap thousands of fish, which are cleaned and dried for future consumption. Occasionally the crops on a section of the river fail, and it is only the swift action of the authorities in requisitioning supplies from other districts which prevents a state of famine. It is a complaint of the French that the river population is too sparse to exploit fully the potential wealth of the inundated areas by widespread cultivation. The French have been in occupation for only thirty years, and much more time must elapse before the damage caused during the centuries of anarchy which followed the overthrow of the Songhai Empire can be repaired.

The real wealth of the country lies in its cattle. When I left Kabara towards the end of April, the Niger had already fallen considerably, and exposed great expanses of tall, rich grass, which was being devoured by immense herds of cattle, sheep, and goats. Some idea of their vastness may be gained from the

fact that in the region administered from Timbuktu alone, the herds of cattle number over one million animals. These herds belong to the nomads, who at this time desert the interior for the river-banks and islands. Enormous quantities of hides and skins are exported to Europe each year from this source by the trading companies. The nomads, however, seem reluctant to dispose of their flocks, and only sell when compelled to by dire need for money to pay taxes or purchase clothing. For this reason, on several occasions during my stay at Timbuktu meat was unobtainable.

On the 400 miles of the river in the Sudan Colony below Kabara there are only five places of importance, all connected by the telegraph line which runs along the Niger as far as Nigeria. Four of them are villages situated at strategic points, and owe their expansion solely to the establishment of administrative posts in their vicinity. The fifth is an ancient capital, which has been revived.

The village of Rharos recently became the administrative headquarters of a large territory south of the river. These headquarters had previously been in an isolated position in the interior. Already the work of transition is well advanced, and straight avenues, lined with young trees, separate the finished from the unfinished buildings of the new settlement. Unlike Rharos, the best days of Bamba are over. Bamba, until a few years ago, was an important military post; but has now been abandoned and its buildings have fallen in ruins. A small population still remains in the village, where there are a few native stores to supply the needs of the nomads, whose flocks wander about in the cool shade of luxuriant acacias.

Near the small village of Salia Koira, the Niger is traversed by a chain of great rocks, which mark the entrance to the river corridor of Tosai. At the narrowest point of the defile the Niger does not exceed 100 yards in width, and the water rushes through with much force. The possibilities of Tosai for the generation of electrical current seem enormous. Beyond Tosai the white fort of Burem dominates the village lying below a circle of red cliffs, where the river recoils from a great arm of sand and turns abruptly southwards. Burem is of greater extent than the two previous places, due to the companies of native soldiers and police stationed in it; but its commercial activities are limited to a small market and a few shops.

The first town of importance below Timbuktu lies 60 miles from Burem. This is Gao, the ancient capital of the Songhai Empire. Gao, or Gogo, is a striking example of what an advertising manager would call non-publicity. Almost every one has heard of Timbuktu, no matter how vague their ideas regarding its geographical position may be. Yet few know anything about Gao, although it was once much more powerful than Timbuktu. Twenty-five years ago all that remained of this great mud city was the tomb of its kings and a group of mat huts. To-day, a town, European in plan, stands on the ashes of the old capital. The neat mud-brick houses are in regular blocks, separated by broad, tree-lined streets, and the long water-front is a place of continual movement beneath rows of acacias. Gao has become the Sudanese base of a motor-car service which crosses the Sahara from Algeria in the cool season. It is also proposed as the terminus of the projected trans-Saharan railway, and the number of buildings in course of erection testify to its growing import-

ance. The relative proximity of Gao to the richer colonies farther south has drawn to it much of the trade that formerly belonged to Timbuktu. There is a flourishing market, and itinerant traders from Nigeria and the Gold Coast come to it to purchase cattle, which they drive to these countries where a higher price is paid for meat. Increased prosperity has caused an increased population, and the channel leading from the Niger to the town is bordered by extensive rice fields. Gao may soon surpass its rival, and even now the vigour of the new life flowing through its streets is in marked contrast to the moribund atmosphere of Timbuktu.

The last post in the Sudan Colony is Ansongo, a quiet little place, whose chief feature is decorative gardens on the water-front. After Ansongo, the Niger changes in appearance. The southerly course commenced at Burem takes it beyond the influence of the desert and the banks become more thickly wooded. Islands divide it into narrow channels, in which a series of rapids form a serious obstacle to communication by water between the Sudan and Niger Colonies, during many months of the year. The most dangerous of the rapids is at Labazenga, on the boundary. Nothing has been done, by means of explosives or otherwise, to facilitate the passage of canoes and barges through these channels, and to keep the river open for traffic for a longer period. When at Ansongo I saw the sections of a small steamboat, which had been there for some time and would remain until the Niger rose sufficiently, months later, to permit transport to their destination in the next colony.

Beyond the rapids the course of the river remaining in French territory is free from rocks; but up to the present the only craft on it is hand-propelled, and the steam vessel lying at Ansongo is the first of several to be employed in speeding-up river transport. The neglect of this part of the Niger has no doubt been due to the presence of good roads, which radiate in all directions, in the colonies abutting on it. Formerly, motor transport served the more urgent needs of the posts in the Niger Colony; but since the capital was transferred from Zinder to Niamei, river traffic has greatly increased.

Tilaberi is the first place of any extent below Ansongo, and the fine village, near the residence and offices of the administrator, is divided into separate tribal quarters. A large island lies in the river opposite the village, and a stream of canoes conveys its inhabitants to the market on the mainland. The villagers cultivate small crops of cotton, which they weave into cloth on crude looms. The beautiful gardens and plantations of palm and banana trees which surround Tilaberi give it the appearance of a park.

The village of Gothei, on the Upper Volta side of the Niger, half-way between Tilaberi and Niamei, is famous for its market. A vast open space between the village and the river is used as the market-ground. The day I was there the whole of this area was covered with a moving mass of humanity, goats, donkeys, and humped cattle. Innumerable small straw shops were full of beads, cloths, scarlet-coloured spices, tobacco, and heaps of red onions. Bars of copper and bottles of cheap European perfumes were also for sale. Such a multitude surpassed anything that I had seen before along the Niger.

Niamei, the new capital, stands on a plateau above the river. The European population numbers sixty, and is increasing as rapidly as accommodation can be got ready for the Government officials. This had been the site of the capital

before its establishment at Zinder, and fine roads, gardens, and the Moorish palace of the Governor still remain. Motor cars and ice, however, are the few luxuries which life there has to offer. In the course of conversation, the Governor revealed to me some of his projects for the welfare of the country. The central administration is to be removed from Niamei to a more suitable situation a little farther up-river. The Niger is to be harnessed to provide unlimited electric current for motive-power and illumination, and the rapids above Tilaberi are to be cleared as soon as possible. These are schemes which will require both time and money for their execution, but they will develop the richest section of the colony, which, outside a narrow margin along the bank of the Niger, is a thinly populated desert territory. The Governor told me that the work of extending the railway in Dahomey to the Niger was about to begin. Later, this line will form a junction with the trans-Saharan railroad in the region of Gao.

The village of Sai, where Barth first saw the Niger, is one day's journey from Niamei. It is buried in a forest of low trees on the right bank, and tsetse flies by day and clouds of mosquitoes at night have forced the administrator to take up quarters well away from the river. From Sai to Gaya, on the Nigerian frontier, the Niger flows through a wilderness from which man has been driven by the activities of the tsetse fly. The banks are masses of broken sandstone, fenced by almost impenetrable forest, interlaced with giant creepers. Islands, which divide the river into two arms, are covered with the same thick bush. Gaya is simply an administrative post that has become the gateway through which everything and everyone passes coming from or going to the West Coast via Dahomey. There is a scarcity of river craft here, and canoemen on the British side are induced to come across the border and assist in transporting the supplies, which arrive from the south, up to the capital.

In crossing from French into British territory there is nothing to indicate the political change. The Niger flows with its usual placidity, although it becomes much narrower. The point of most interest is a sudden increase in the density of the population on the banks. There are flourishing villages everywhere, and just inside the frontier the thatch-roofed town of Ilo stands 2 miles from the river, in the centre of a cultivated region. The government of the country is in the hands of a Native Administration, and an Emir resides at Ilo. Lack of good communication has isolated this district from places farther east, with the result that much of its produce passes over into Dahomey.

From Ilo to Yelwa the enterprise of this river population of energetic Hausa people is shown in the tracts of land under cultivation, and the markets in all the important villages. Yelwa is also the headquarters of an Emir, and the only European administrator before Jebba is stationed at it. Between Yelwa and Jebba, where the Nigerian Railway crosses the Niger, and where my journey ended, the worst rapids on the river are encountered. This section of the Niger is therefore little used for commercial purposes, except during the rains, when the fair-weather roads are impassable, and the Niger Company employs many native canoes to send stores up-river. The most dangerous rapids are at Bussa, Bobaro, and Uwuru, and the Nigerian Marine Department has carried out splendid work in making the first two passable for

most of the year. At present they are blasting a new passage, 20 feet deep, parallel to the Uwuru rapids, which will obviate the portage necessary at this spot when the river is low. Thousands of pounds have been spent on the work of improvement.

I arrived at Jebba at the beginning of June. The tornado season was in full swing, and I forsook my frail wooden canoe for a comfortable railway carriage.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: To-night Mr. Scott is going to describe a journey which he made a little time ago from the south-western portion of Algeria, where the railway ends, south-south-east across the Sahara to Tamanraset, and then south-west to Timbuktu. So far the journey was accomplished on camels. At Timbuktu he took canoes and went down the river Niger, from Timbuktu to Jebba. That part of the journey, Mr. Scott assures me, is more interesting than the first, although it took less time. The whole journey took nine months, of which the portion from Timbuktu to Jebba took forty days, so you will realize that it is quicker to travel in a canoe, particularly if going down-stream, than on a camel across the Sahara. The part of the journey which Mr. Scott did across the Sahara will be interesting to us for several reasons, partly because we have had one or two lectures lately on that part of Africa. First the excellent account that Mr. Francis Rodd gave of his journeys from Nigeria to the Aïr district, and then to Timbuktu; secondly, the admirable account that Mr. Cameron gave us of his journey right across the Sahara from Nigeria to Algeria, and now we are about to listen to Mr. Scott's account of his journey. I think if those present will study the account to which they are to listen to-night, the account by Mr. Francis Rodd and that of Mr. Cameron, they will get a very good idea of the Sahara.

Mr. Scott then delivered the lecture printed above, and a discussion followed.

The PRESIDENT: We have with us Mr. Tweedy, who not long ago was at Rejaf at ', with a friend, suddenly decided to cross Africa to the Niger in a motor car. Having reached Nigeria they travelled northwards into the Sahara and on to Algiers. We shall be glad to hear a few words from Mr. Tweedy.

Mr. OWEN TWEEDY: It is with some diffidence that I speak about the Sahara after hearing Mr. Scott's account of his long camel and canoe trek; for I travelled like a vandal in a car. Such qualifications as I have to speak at all rest on a journey from Gao to Reggan in a 10-cwt. lorry which looked exactly, and still looks—for it is in London—like a grocer's van.

Our party consisted of three, Captain Richard Crofton, myself and an excellent Swahili cook. Before we reached the Niger we had covered 3500 miles across Africa from the Nile in the Southern Sudan to Gao, passing through Belgian Congo, up the waters—and very marvellous they are—of French Equatoria to little-known Lake Chad; then across the north of Nigeria along the fringe of the Southern Sudan to the Niger and Gao. The object of our journey was, as a matter of fact, a little more highbrow than our President has said. We wished to study and to see and learn as much as possible about the natives, and something of how the Arab penetration from the north mingles with the paganism of Central Africa. We saw various kinds of garb, heard various kinds of tom-tom, and had an opportunity of studying various kinds of administration. The most interesting feature of those administrations was the way all—the Belgian, the French and, above all, the British—are tackling the tsetse-fly and sleeping sickness problems. But I won't keep you on that journey. When we arrived at Gao

we felt that we had finished with thinking about other things and other people, and that now, with the Sahara ahead, our job was to think for ourselves.

Like the chicken which crossed the road, our sole object in crossing the Sahara was to get to the other side. We wanted a short cut home, and a cheap cut home. Our car was still going very well; so we made as many inquiries at Gao as we could and asked various people to come and look at it and see if it was in order. We elicited a mass of information, mostly very inaccurate. Some represented the desert which lay before us as being a tennis court over which "Messieurs, vous pouvez rouler a tout vitesse!" Accordingly, with the same confidence as that which cheered the innocent breast of the chicken, we sallied forth on April 16, just eight weeks ago, with a full and carefully calculated load of petrol and water and a good deal of food, to cross the 850 miles which lay before us.

The route which we took was more or less that of the Greenwich meridian, and we proposed, in order to guide ourselves, to follow the ruts of the motor-service which in comfort and safety runs from Gao to Reggan during the three winter months. For convenience' sake our route can be divided into three stages. The first, some 280 miles long, is through scrub such as many of us know in the Sudan and Equatoria. We saw an occasional human: we saw a few gazelle; but as the desert approached vegetation became increasingly sparser, and signs of life more and more rare; while at Tabancourt, some 100 miles out of Gao, we passed the last well we were to see until Reggan. The second stage of the journey crosses the centre of the Tanezruft, over the eastern fringe of which Mr. Scott passed on his journey. This stage is 400 miles long, and its southern approaches are across some of the nastiest country I have ever seen—long, wide flat-bottomed valleys and low soft dunes with treacherous ascents and descents and 2-mile stretches of shifting sand. Past these obstacles, the Tanezruft itself opens out limitless in its flatness, looking like a picture taken from the side of a liner of the horizon and the sea. Although it is devoid of water, devoid of life, devoid of grass, devoid of wood, in fact, devoid of everything, it is not a bad part of the journey for travellers such as we were. For long stretches the going is quite good, and even where, in almost imperceptible undulations, sand has drifted, you get along quite nicely; sometimes, indeed, it is quite pleasant. Past this is another 100 miles before the second stage is over. Those 100 miles slope down to the north, and, as is the way of slopes when they face prevailing winds, the sand has drifted in hummocks, some wide, some not so wide, all very unpleasant and the going very difficult.

The last 150-mile stretch of the journey to Reggan passes through a tumbled mass of sand-hills, ridged this way and that, and spattered with long sand-drifts to which there seems to be no bottom, and the consistency of which resembles boracic powder and sometimes chalk.

I have given rather a bleak picture of this crossing and this route; but the fact that I speak thus bleakly is because we had rather a bleak time. But I do not wish anything that I have said to be interpreted as a criticism one way or the other of the route. Personally I think it is a possible route for the future, and I speak seriously. But you must have a proper car and it must be properly driven; and the only car to negotiate it is one which has six wheels and a double drive, or, if not, twin wheels; anyhow, the tyres must be thick and wide, and there should be some arrangement on the radiator which will keep water from boiling away. If one knows how, it is possible to preserve 50 per cent. of the water. Our car was fitted for none of these contingencies! We had very narrow wheels, and we had no device on the radiator which would save any of our precious water. Furthermore, we timed our departure precisely so as to be punctual for

three very unpleasant sandstorms which delayed us the third, fourth and fifth days of our journey.

On the whole we learnt a good many lessons, some of which might be passed on with advantage to others who would follow in our ruts. In the first place, thanks to our tyres, we were sand-bogged no less than forty times. Every time that happened it meant, at a minimum two, at a maximum six, efforts before we were clear; and they are most exhausting. First you unload; then you dig and put the floor boards under the back wheels, then you push, and then probably you sink again. Anyhow, when you have not sunk, as often as not, you have to carry what you have unloaded some 100 yards behind to where the car has at last been able to find some solid ground on which to rest some 100 yards ahead. Then you re-load and carry on as best you can. On the third day out we were bogged twelve times, and in twenty-four hours we made 34 miles. We were so upset about it that at mid-day, facing a valley which only a Bunyan could describe, we decided that we must jettison hard. To-day there are on a crest overlooking this very unpleasant valley a red blanket which I bought in Khartoum, a gun, several books, a good deal of medicine, some spare springs, an axle or two, several spare parts which might be useful to anybody who has a Chevrolet car, and a good deal of rather inferior personal raiment. If anybody ever finds them they are quite welcome to them. However, we made our sacrifice and we lightened the car, which was the main thing. We did, of course, get bogged again, but when we did it was less trouble pushing and getting free.

Secondly, there is the question of water. Here again is a hint. Water boils away very quickly no matter what you arrange, if you drive by day. The only thing to do is to drive by night; and if you do that, owing to the unevenness of the surface—as we used to say—it is necessary to dip your lights. And I can assure you it is not at all pleasant driving for nine hours at a stretch with dipped lights beyond which any peril may lurk. But it pays—and there is more water in the morning.

We had three other slight incidents which are of passing interest. First, our only watch stopped: so we lost all contact with time. Secondly, our speedometer broke and we lost all contact with distance. Lastly—and this was a foolish thing to do—we lost our starting handle, with the result that every time we stopped for water, or whatever it might be, we wondered whether the self-starter would work. But it did work; and on April 21, a fine windy Sunday morning, we arrived at Reggan just in time to stop solicitous French officers from sending out a break-down party from Reggan, a camel patrol from Quallen, and an air fleet from Adrar to rescue us, as they feared the worst.

I have given you a picture which is really more or less what we thought as we went along; but the route which we have crossed and which we commented on in terms sometimes polite and sometimes not, is really a possible route. And not only that: it is being taken seriously by the French. On our way to Algiers we met the full team of a French railway survey party. They had been out for six months on the route we had just crossed, and they had plans for a trans-Saharan Railway in their pockets which was to stretch from Burem on the Niger, to link up with Djelfa, the southern terminus of the railway which runs to Algiers. Again, when we were in Algiers we were shown plans, surprising as it may sound, of a motor race which is going to be run next year in celebration of the centenary of the French occupation of Algiers. The hardy competitors are expected to run from Oran on the Mediterranean, down to Reggan; and thence across the route we travelled to the Niger. At Gao they will turn half-left and come up more or less by the route which Mr. Scott followed to Algiers—if they ever get there.

Most interesting of all, in Paris I had an interview with the head of the trans-Saharan Motor Service. He has plans—and he is a serious man of enterprise—which will make his trans-Saharan Service an all-the-year-round service to Gao. There subsidiary motor services are to be organized to carry hardy tourists and hardy officials west, east, and south. He has lines marked on his map to Dakar in Senegal; to Lagos, and Stanleyville; to Nairobi and Mombasa; and, most illuminating of all, to Bulawayo, Johannesburg and Cape Town.

The PRESIDENT: Mr. Scott has given us a graphic account of his journey, first of all across the desert and then along the River Niger. I think that from his lecture we have gathered that that great territory which the French own is, after all, only a space to be covered; it is of little value in itself. It is being crossed more and more frequently, and, as Mr. Tweedy has just said, opportunities for crossing it in a car will become greater and greater as time goes on. Mr. Scott has given us a clear idea of the relative valuelessness of that territory, and also an excellent picture of the cultivated and highly populated country that is entered when one reaches British territory in Nigeria. We are grateful to Mr. Scott for his lecture, and for the slides he has shown. We hope that in future we shall learn more about this stretch of the Niger which he has described, from Timbuktu to Jebba. In the name of the Society I thank him.

Mr. V. C. SCOTT O'CONNOR sends the following contribution to the discussion: I should like to take this opportunity of acknowledging, on behalf of Mr. Leonard Scott and myself, the courtesy and genuine kindliness extended to him during his prolonged stay in the desert regions of the Sahara, and throughout his trek to Timbuktu, and down the Niger to the British border. Mr. Scott, as a very young man who had still to win his spurs, was told at the outset of his journey that he was welcome in French Africa; and that all that could be done to facilitate his travels would be done for him. This magnanimous undertaking was fulfilled to the letter; even when unlooked-for difficulties arose in connection with his journey. In the case of my own first journey in Morocco some seven years ago, I was treated with the same liberality by Marshal Lyautey. Recently again, through the Marshal's intervention, I was permitted, under some pressure of time, to cross the Grand Atlas to Tarudant, and to make acquaintance with the Atlas chieftains and notabilities, by whom I was well received at each stage of my journey, through country which, though now made safe for a traveller, is not yet open to the general public. If I refer to these matters it is because I feel, apart from the natural gratitude of a traveller who has been kindly entreated, that our fortunes are so interlocked with those of France in Northern Africa and upon the Equator, that it is of the highest importance that we should appreciate each other, not only as neighbours, but as two people engaged in our separate ways upon the same high adventure. The fact that our political ideas and methods are in some respects unlike does but add to the value of personal contact, sought after in a spirit free from prejudice, and inspired by good-will.

THE QUEENSLAND COAST AND THE GREAT BARRIER REEFS: *The second part, continued from p. 257, of the paper read at the Evening Meeting of the Society on 4 February 1929, by*

J. A. STEERS

6. *Sand and Shingle Spits*

(*a*) *Island Spits*

A characteristic feature of nearly all islands in the reef area is the occurrence of a sand or shingle spit on their lee sides. This, whilst applying more particularly to the high islands, is noticeable on some of the low wooded islands as well. Usually these spits are rather stubby and short. They are nearly all triangular in shape, the base of the triangle adjoining the island. The shingle is normally piled up into a series of ridges by the waves. These ridges stand very steep, the composition of coral shingle allowing a much steeper angle of rest* than can ever occur in shingle beaches elsewhere, as, for example, on our own coasts. If the spits are mainly of sand, the ridged appearance is much less noticeable, and may be absent altogether. As a general rule the spits are well clothed with vegetation, which resembles that which occurs on the cays and low wooded islands, with some admixture of the flora of the island to which they form appendages. *Casuarina* is perhaps the most characteristic tree.

As the south-east wind is the prevalent wind, and waves from that quarter have most influence on the shores of the islands and mainland, it is natural that the spits should form on the north and north-west sides of islands. Whilst details are clearly largely dependent upon the shape and amount of shelter any island can give, it is normal for the spits to point between north and west. The length to which a spit may attain seems to be a rather complex problem, depending amongst other things on the amount of material available, the protection afforded by the island to which it is attached, the amount of open water on the weather side of the island, the material of which the island is formed, and the size of the associated fringing reef. In a general way, as might be expected, the bigger islands have bigger spits, *e.g.* Dunk Island. Where there are many small islands close together, as, for example, in the Family Group, or the scattered islands between Magnetic Island and the Palm Group, the spits form a very striking feature: the contrast of the high and low ground with their different types of vegetation is very noticeable.

Occasionally the spits have become tombolos, and neighbouring islands have been joined together. This has happened at the north-east end of Hinchinbrook, the largest and highest of the inshore islands. Cape Sandwich, Cape Richards, and a third, unnamed, cape,† together with a few small residuals, are really several islands which have been joined up by sand spits growing out from the main island. Ramsay Bay is outlined with dunes growing on the main spit: behind the spit and running back into Missionary Bay are very extensive mangrove flats cut up by many meandering creeks.‡

Even on such small islands as the Turtle Group well-developed spits occur,

*On Snapper Island a case of actually overhanging but quite incoherent coral shingle occurred. Angles as steep as 60° are very common.

†This cape is to the north-east of Hinchinbrook Island and faces Missionary Bay.

‡See Andrews, *Proc. Linn. Soc. N.S.W.*, 1902, pp. 146 *et seq.*

some of which are beautifully recurved. The formation of beach rock on these spits, and then a change of conditions causing the wearing away of the old spit and the formation of a new one running in a rather different direction, is one of the main causes of the inequalities so noticeable in the dip of old beach rock formations. This is often intensified if uplift has intervened.

There seems to be little doubt that these spits are traceable to the influence of the south-east winds. If the island is small and waves come round on either side, the spit is usually small and stubby, as in the Family Islands. These islands are too small to form any marked protection, and the waves coming round either side leave a small triangular space of relatively calm water in which sand can be piled up. Once a certain critical length is attained, growth ceases: the waves washing round the island soon meet and tend to obstruct the lengthening of the spit. Where the island is bigger, or where the waves are really only effective on one side, the spit may grow much longer, *e.g.* Hinchinbrook and Dunk Islands. Both these islands are close to the mainland and only occasionally can waves of any magnitude come in on the mainland, or sheltered, side. Whilst attributing the main construction of these spits to wave action, it is well to note that the major currents, during the season of south-east winds, come from the south-east, and that these currents may help in modelling the spit.

6. (*b*) *Mainland Spits*

Along the mainland coast there are many examples of sand and shingle spits to be found pointing between north and west. Throughout the whole length of the Queensland coast it seems that the major drift of material is to the north. Again, in New South Wales this is the case. Around Sydney there are many excellent examples of lagoons formed by sand and shingle drifting across re-entrants in the coast. Some of these particular spits may be due to reverse or eddy currents.* Deewhy Lagoon and Narrabeen Lagoon are familiar to many. In South Queensland occur some of the greatest dune areas in the world. Stradbroke Island, Moreton Island, Great Sandy Island (Frazer Island) are some of the best-known examples. On Moreton Island the dunes reach the exceptional height of over 800 feet, and apparently do not everywhere rest on rock. These islands would appear to be really elongated spits or offshore bars on a grand scale.

Agassiz (*op. cit.*, p. 96) contends that Great Sandy Island and the islands† fringing Moreton Bay "once formed part of the adjoining mainland; that they have gradually been separated from it by erosion and by the combined action of the scour of Brisbane and of Mary Rivers. . . ." This hardly seems to be the case: it is more probable that they are really of the nature of ordinary sand spits built up by waves and currents running to the north, and now covered by vast dunes. Agassiz then goes on to say ". . . while Breaksea Spit, with the adjoining shoals, covered with sand and dead corals, parts of which are awash, is the remnant of a former extension of Frazer Island, stretching about 17 miles beyond Sandy Cape." This is very improbable, implying, as

*See Halligan, *Proc. Linn. Soc. N.S.W.*, vol. 31, 1906, pp. 619–640.

†Some of these islands contain outcrops of solid rock, but in the main they are dune islands (see Andrews, 1902).

it does, the destruction of an island or spit which once continued Great Sandy Island northwards. From the evidence of the lightship referred to earlier in this paper, and also from the known set of currents and waves, there is no reason to think of Breaksea Spit as other than a normal sand spit built up in the usual way. In its exposed situation it certainly suffers much damage, alternately being partly cut off in storms and rebuilt. But this is very different from regarding it as "a former extension of Frazer Island."

There are many minor examples of this type to be found all along the coast, but reference need only be made to one or two. North of Cape Upstart is Cape Bowling Green. This is a long, low and quite typical sand spit formed of ridges. It is partly covered by vegetation, and at its distal end has several examples of recurved ridges. It encloses a low swampy area in part overgrown by mangroves. The relation of this spit to the delta of the Burdekin suggests the possibility that the material of which it is built is, to some extent, supplied by the river. It was not possible to make any detailed examination, but enough was seen of the spit to make it seem well worth individual study. There is a brief reference to it in Jardine's paper on "The Topography of the Townsville Littoral,"* where he says: "Its presence appears to be due largely to the distribution of material by long-shore currents in the area." A very short visit suggested that an ecological botanist would find some very interesting work here.

Allusion has been made to tombolos tying islands together at the north of Hinchinbrook Island. On the mainland there are also examples. Tam-o'-Shanter Point, near Dunk Island, is one such. Another, better known to members of the Expedition, occurs at Port Douglas. The island on which the light and part of the township stand is tied to the mainland by a sand spit.

There is, then, no lack of examples testifying to the work of waves and long-shore currents on these coasts. We may mention one other effect of these agents which has found notice in a paper by Hedley and Taylor.† These authors point out that many reefs are convex to the south-east. They contend that if a reef patch commences to grow, it will, if the patch lies athwart the prevalent winds, grow in such a way as to produce two horns pointing down wind. Cairns Reef is given as an example. It is probable that such crescentic reefs are produced in this way, but there are many exceptions. Further, growing coral is not quite so amenable to exterior forces as is sand and shingle. Nevertheless, given the suitable conditions, it is reasonable to expect a reef to grow in this way.

Apart from the spits so far described, note must be paid to those forming across river mouths. Some of the Queensland rivers are deflected northwards in this way. The best example seen was the bar across the Mulgrave-Johnson river.

7. *Evidences of Recent Elevation*

Along the Queensland coast and on the neighbouring islands there are many traces of recent uplift to be found. A good deal has been written on

*Reps. Gt. Barrier Reef Comm., vol. 2, 1928, pp. 70–87.

†"Coral Reefs of the Gt. Barrier," etc. *Reps. Aust. Ass. Adv. Sci.*, Sect. C, 1907, p. 397.

this subject and some rather diverse results have appeared. One reason for this seems to lie in the question of the actual formation of benches. It is well known that marine abrasion can very easily cut a rock platform; but at what level, with respect to mean sea-level, or other chosen datum, does this occur? It has been argued by Jardine* for this coast that cutting can go on at different levels at one and the same time. This is an assumption which does not seem to be in accord with the facts as they present themselves. It is probable that the main cutting action which produces a bench takes place at or below mean sea-level. High-water benching, except perhaps under certain peculiar circumstances, is improbable, inasmuch as the water does not stand long enough at these higher levels to have a chance of forming benches. It may be argued that in soft or even relatively hard rocks some benching could occur at this level. But surely any lower benching, which can go on at times when the water does not reach the higher level, would sooner or later undercut the upper benching?

Another point is that observers are by no means in exact agreement as to levels at which benches occur. Many often refer a particular bench to high tide. Does this mean high springs or an average high water? It is by no means easy to make any definite suggestion in this respect in the absence of instrumental methods for determining a mean sea-level. But the difficulty is partly overcome by referring to the level to which the rock oyster (*Ostrea mordax*) reaches.† This seems to be remarkably constant, and was used by the late Charles Hedley.‡ Reference to a tide-level is made difficult by the fact that high-water drift marks may be piled up very high on the beach by waves. As far as our observations went, the upper limit of the rock oyster seems to approximate fairly closely to high-water neaps. In the absence, then, of more precise determinations, it will be helpful to refer benches, as far as is possible, to this level.

There are two well-marked benches to be found on this coast. The upper and less conspicuous bench is about 8 feet above the oyster level. The lower varies from 1 to 2 feet above this level. This latter, apparently, is referred to present erosion by Jardine. With this we are not in agreement.

This lower bench is remarkably well developed in certain places: special mention may be made of Cape Flattery, where it is cut partly in hard much-contorted and metamorphosed Palaeozoic rocks, and still more (in the northern part of the cape) in sandstones and conglomerates, and Stephen's Island in the South Barnards, where it occurs in volcanic tuffs. On this island the bench occurs on all sides: by no means is it limited to the weather side. On Double Island there is an interesting example of this bench, which is being colonized by mangroves. Whilst recognizing the conditions with which mangroves can contend, it seems rather difficult to associate any active cutting with the spread of these trees. The major bench described by Richards and Hedley§ on Flinders Islands apparently corresponds to this same level. Weather con-

*Reps. Gt. Barrier Reef Comm., vol. 1, 1925, pp. 111–130.

†This applies to much of Queensland: I am unable to say if this datum can be used farther south.

‡Reps. Gt. Barrier Reef Comm., vol. 1, 1925, p. 61.

§*Ibid.*, pp. 1–27.

ditions made landing on this bench difficult, but as far as could be seen from the launch there is little doubt that it belongs to this same level. There are many other examples, Archer Point, Cape Upstart, etc., but little is gained by making a full list.* The cases noted above are particularly well developed and may be taken as type examples.

The higher bench, about 8 feet above the oysters, is rarer. Hedley† has described a case in the North Barnards: this we saw, and it seems to correspond with a similar level on the north side of the entrance to Mourilyan Harbour. There also seemed to be traces of it at Cape Flattery, and Jardine‡ has described some occurrences at Archer Point. A visit to this place left some doubt about the existence of this bench, but there certainly seemed to be traces of it just to the north. Many other occurrences of raised benches have been recorded by other writers, and as they occur at these two levels we may be quite definite in assuming a relative movement of emergence§ in at least two stages and of very recent date on this coast.

Whilst at Brisbane the opportunity was afforded me of seeing another example of the lower beach at Sandgate. This is thought by Bryan and others to correspond with certain low-level river terraces which also occur in the neighbourhood. This low-level bench is well marked in all Eastern Australia. A very striking case occurs at Long Reef a few miles north of Sydney.‖ Here the bench attains a width of about 400 paces or more and is cut in the Narrabeen shales. It is well worth noting that a gentle anticline is cut across by this bench, an argument which strongly favours marine planation. It is difficult to see how the formation of such a bench as this can in any way be related to the bedding of the rocks. This same bench occurs all along the Sydney littoral: a good example occurs on North Head at the entrance to the harbour. Daly¶ and others have also called attention to its development in many of the Pacific islands. There can be little doubt that it is to be correlated with a widespread movement of sea-level: its uniformity of height and its presence over such vast areas both point to eustatic movements of sea-level.

It is generally conceded that this bench is of very recent date. Indirect arguments for its youth are found in the freshness of the bench itself; the occurrence of cliffs behind it which are still steep (*e.g.* on Double Island, Stephens' Island, etc.); and the absence of any well-marked bench at a lower level. Richards has described a minor and present level bench below it in the Flinders Islands, and there seemed to be traces of this lower bench at Cape Flattery. These, however, have not yet had time to attain any size.

Apart from rock-cut benches, there are also to be found other evidences of this same eustatic movement in the low wooded islands. In the description of these islands stress has been laid upon the almost universal occurrences of beach rock and coral conglomerates. Very often both beach rock and

*For further details see Jack and Etheridge, 'Geology and Palaeontology of Queensland,' pp. 613 *et seq.*, and Jardine, *op. cit.*

†Reps. Gt. Barrier Reef Comm., 1925.

‡*Ibid.*, vol. 1, 1925, pp. 111–130.

§Probably we have to deal with eustatic movements as postulated by Suess (see Jardine, *op. cit.*).

‖See Jardine, *op. cit.*

¶Carnegie Institution Washington, Pubn. No. 340, 1924, pp. 93–143.

conglomerates occur at levels which strongly suggest recent uplift. At first we were very sceptical about referring these features to uplift. Unfortunately the origin of beach rock, and the conditions under which it can be formed, are still subject to dispute. There seems, however, to be a consensus of opinion that its formation is not probable above the level of high water at ordinary spring tides. Yet there is little doubt that in many of these islands beach rock and conglomerate occur at higher levels. Agassiz, who interpreted these conglomerates differently, was the first to bring the point to the front, and his descriptions of Middle Island near Bowen are important in this respect. Of this island he writes:

". . . came upon a fine exposure of a coarse conglomerate, similar to that described by Jukes. This conglomerate beach rock is elevated fully 8 feet above the highest high-water mark. . . . The faces of the elevated conglomerate exposed to the action of the sea were pitted and honeycombed much as the aeolian rocks in the Bahamas where exposed to the force of the sea. . . ."*

As pointed out by Stanley, Agassiz regarded this as part of an elevated reef, a conclusion which is now unacceptable. Stanley,† in 1925, also examined this exposure, and notes that it is a feature which is found on many other islands. The slabs of rock dip about 7° or 8°, but by no means is the dip regularly seawards. It will be helpful here to quote from Stanley's paper:

"The fringing reef covers at high tide. Five feet above the high-tide mark is a bench 12 to 15 feet wide. This is cut in the soft conglomerate and does not show on the granite shores of the island. It cuts horizontally across the basset edges of the dipping beach rock. Behind the bench is a bank, 6 to 8 feet high, consisting of slabs of blackened beach rock apparently *in situ*. Behind this again is an extensive, flat sandy area from which the island slopes up. Such a section is comparable to that recorded by Andrews at the South Palm Island, Fantome Island, and elsewhere."

The present writer agrees entirely with Stanley's main contention—a recent elevation. The only point of difference in detail would be the height above high-water mark. Stanley suggests 5 feet. Consideration of other cases and the position of the rock oysters at this place, lead rather to the conclusion that the platform cut through the basset edges would be very nearly awash at high-water springs. This, after all, is only a small point, but it was noted that high-water drift-lines were up to and even above the level of this platform. This, however, is partly due to waves. Nevertheless, there seems to be little doubt that this platform corresponds with those benches which are cut in solid rock and which have been mentioned already.

Particular attention has been paid to this case, as it has become a classic example. It is, however, as Andrews notes, no isolated case. The present writer saw several such examples farther north. The suggestion of their elevated nature first attracted attention on the western end of Howick Island, where there is a pavement of very rough coral conglomerate, containing some very large coral masses. This, as in all other such cases, is suffering much from wave erosion at the present time, and its seaward edge is extremely

Bull. Mus. Comp. Zoo. Harvard, vol. 28, No. 4, 1898, p. 107.
†Reps. Gt. Barrier Reef Comm., vol. 2, 1928, p. 36.

jagged. Another striking case was noted on Ingram Island; here, as at Middle Island, there were great slabs of beach rock which had been cast up above the platform. In this case they certainly did not appear to be *in situ*. At Houghton Island, in the Howick Group, there is a very fine platform, and, as noted elsewhere, it is here that a very pretty example of an unconformity in the beach rock was observed. A very hasty, and in fact unintentional, visit was made to Camp Island, south of Cape Upstart. As far as could be seen this presented even clearer evidence than any other case. It would well repay special study. Similar evidence exists on many other islands, but further details are unnecessary.

Before leaving this question, another point is suggested. Stanley notes on Middle Island, as already quoted, a bank behind the bench in which the slabs of beach rock are apparently *in situ*. This bank is a puzzling feature. If, as appears very probable, these slabs are *in situ*, may we not find here a suggestion of a double uplift—the higher platform corresponding with the higher bench noted by Hedley and others as well as ourselves? Sufficient evidence for such a correlation is lacking, but it is a point which might, perchance, repay investigation.

There is, then, abundant evidence over all the Barrier Region of recent uplift which took place in two stages and over much greater areas in the Pacific in one stage at least. Circumstances point to a very recent date for the second elevation (lower bench), and, as noted by Richards and Hedley,* the probabilities favour a relatively rapid movement of uplift. The question of the amount of the uplift is rather difficult. In the absence of unpublished data, as far as Queensland is concerned, conversations with those interested in the benching all suggested an uplift of from 12–15 feet for the lower bench; with this the writer agrees. This implies that it was cut rather below mean sea-level. The upper bench, about 6 to 8 feet above the lower, therefore, points to a rise of the land relative to the sea, of about 18 to 23 feet. It is, perhaps, well worth noting that the bench at Stephen's Island was not quite awash at high-water neaps. Our visit there coincided with neap tides and a calm sea, and we were able to see that the bench was not covered at high water. Further, the oyster line was quite well marked, and coincided very well with the high-water level at the time of our visit.

If the correlation of benches on high islands and the occurrence of beach rock and conglomerate platforms on low wooded islands be valid, the question arises, do reefs which have no islands of any kind on them afford any such evidence of elevation? Any quantitative answer to this question it is not possible to give, but the movement, being so widespread, must certainly have affected the reefs, and it is possible that many of those which dry out almost completely at low water may be taken as evidence of uplift. This question, however, would appear to be soluble on biological grounds, and apart from suggesting the possibility, it is inadvisable to discuss it further in this place.

There is yet another common feature on the Queensland coast testifying to a recent upward movement of the land relative to the sea. Jardine,† in a paper

*Reps. Gt. Barrier Reef Comm., vol. 1, 1925, pp. 1–27.

†Reps. Gt. Barrier Reef Comm., vol. 2, 1928, pp. 70–87. See also Hedley, *ibid.*, vol. 1, pp. 63–65.

on the Townsville area, has drawn attention to the granite residuals rising through a flat alluvial plain. This area is very typical, but similar features elsewhere are common, though they have not yet been examined in detail. Around Townsville there are several granite hills or mountains which are true residuals. These rise with remarkable abruptness out of the surrounding plains, and the impression given to an observer from the summit of any one such residual is that the surrounding plains once formed part of the adjacent sea-floor. Jardine has shown that the case is not quite so simple as this, but finds evidence for a recent uplift of a few feet. In all probability this uplift corresponds with the lowest bench and the river terraces noted at Brisbane and elsewhere.

Townsville itself is situated at the head of Cleveland Bay, which is hemmed in to the south by Cape Cleveland and to the north by Cape Pallarenda. In front, to seaward, is Magnetic Island. Behind are several more or less isolated granite hills. Castle Hill stands practically in the town and is typical. From its summit a very good view of the surrounding topography is obtained.

Joining these hills is the plain, often only a few feet above mean sea-level. The Cape Cleveland residual, for example, reaches a height of about 2000 feet, and the whole mass is about 7 miles north and south by 4 miles east and west. From a distance it appears as an island, very similar to Magnetic Island. Actually it is joined to the mainland by salt marshes and salt-pans, which are 2 feet below the general level of the flats. Dunes occur nearer Cape Cleveland, rising to 15 feet or so above sea-level. Much the same thing occurs to the north around Kissing Point and Cape Pallarenda.

Jack first drew attention to this question and pointed out that many well-borings showed that the flat consisted of alternating beds of clays, sands and gravels. In one case these were not bottomed at 125 feet. He then pointed out that as the bore sites are only 30 feet above sea-level, the substratum of rock (the old land surface) below the alluvium is from 80 to 100 feet below mean sea-level. Rivers could not have excavated channels to this depth, and so he concludes there must have been a subsidence of rather more than 100 feet. On Ross Island (a suburb of Townsville) Jack found evidence of a raised beach. Jardine has found other such evidence south of Townsville. Further, he is of the opinion that practically all the alluvium up to 15 feet above mean sea-level is marine. Hence, all the low-lying plain around the residuals must not be regarded as an uplifted sea floor, as this alluvium reaches up to about 300 feet. Jardine goes on to say:

"It is probable that, resting on an older alluvium (marine alluvium?) there is a veneer of more recent detritus, gradually thickening towards the tableland scarp. The present profile the writer regards as an equilibrium profile for the steeply falling streams laden with detritus from the tableland (during periods of heavy rainfall in the catchment areas) across the level plain. It is certain that, after falling from the tableland, the streams are aggrading on the flats, and it is true that deposits seen in the stream trenches are much coarser and heavier towards the base of the tableland. A slight movement of emergence is apparent along the shoreline of this area."

This area may be regarded as a type example. Jack, Hedley and Jardine have

all commented on it, and the evidence is conclusive. Time and circumstances did not permit any further detailed observations being made here, but bearing in mind this case, it became clear that this area was no isolated example. At Cooper Point, to the north of Innisfail, is another such area. (See Plate, No. 13.) Here there is a beautiful example of a residual mass included within the low ground between Cooper Point and Miller Hill, near Innisfail. The low ground is largely a mangrove flat, and the hills and flat are densely covered with vegetation. Very similar features occur north of Cooper Point, south of Double Point, and between Cape Kimberley and Cape Tribulation.

A study of the large-scale Admiralty Charts, and still more a prolonged cruise along this coast, bring out very conclusively how common a feature these flats are. Enclosed between two headlands, these filled-up bays, more often than not with one or more residual masses rising out of them, occur regularly along great stretches of the Queensland coast. Sometimes the bays are widely open, and then the flat takes on the appearance of a fringe to the mainland coast, but the differences are only those of detail. In fact, it would not be too much to say that such areas are one of the most characteristic features of the mainland shore.

The question now arises, can we see or suggest evidence for this same uplift in a somewhat different type of district? Detailed evidence is lacking, and could only be obtained by difficult field work in uninhabited and often very wild country. Capes Bedford and Flattery are two high masses of rock which are joined to the mainland by great stretches of dunes. These dune areas are really gigantic tombolos, which are now raised above the level of sand spits by the growth of dunes. In fact, we have here, on a very much larger scale, what we have already found at Tam-o'-Shanter Point and Hinchinbrook Island. Assuming a shallow-water area at the commencement between Capes Bedford and Flattery (when they were islands) and the mainland, it would be easily possible for a bar of sand to form and join them to the mainland. But if a slight uplift occurred this process would be made easier, and it seems not unreasonable to see in these two places further evidence of this recent movement of sea-level which has been demonstrated by much more definite evidence elsewhere on this coast.*

In the Lizard Group of Islands a similar feature seems to occur. The main island is topographically separated into two parts, the one consisting of the high peak and larger part of the island, the other of a smaller granite mass. Between these is a low and rather broad valley which consists of sand. Where fresh water occurs it is covered by a thick belt of Pandanus trees, but elsewhere only by thin grass. There is clear evidence at the north end of a sand bar having formed across the valley, and this bar is raised in height by low dunes. As far as could be seen the south end was similar: unfortunately this was not visited. But here again the transformation of a low area enclosed by two spits into a low sandy plain some feet above the sea would be most easily brought about by uplift. Bearing in mind that the present near neighbours of Lizard Island, as well as Lizard Island itself, are surrounded by fringing reefs, it would be interesting to put down a few shallow bores to find out if the foundation of this low valley is a reef which has been first killed and then sanded

*See Andrews *re* Hinchinbrook Is., *Proc. Linn. Soc. N.S.W.*, vol. 28, pp. 146 *et seq.*

over.* Thus, even if Townsville is one of the few places in the alluvial areas giving conclusive evidence of uplift, it is more than probable that similar areas, which so frequently occur on this coast, have been formed in the same way. This probability, I venture to think, becomes, through the circumstantial evidence afforded by the benches, a certainty.

Before leaving this question, a word may be added about certain reefs fringing the mainland. North and south of Donovan Point there is such a reef, and when visited its surface proved to be dead and much encrusted with later superficial growths. There was some living coral in deeper water on its seaward face. Here again evidence of the same upward movement may be found.

Another common feature testifying to this uplift has been noted by Stanley† and others, and, indeed, is apparent in many places visited by the writer. The major islands have been shown to be well dissected by gullies and ravines. The seaward ends of these are now nearly always silted up, and a flat, delta-like plain occurs. As noted elsewhere this may extend as a fringe around part or all of an island. Stanley sees in this, in the Whitsunday Group, direct evidence of uplift. It is, to all intents and purposes, the same type of feature as the flat alluvial plains around Townsville and other places. From features seen in many other parts of the reef waters the present writer has no doubt as to the validity of Stanley's views, and regards these flats as further evidence of recent elevation of the land.

Many writers, *e.g.* Beete Jukes (p. 337) and Maitland (quoted by Andrews, 1902), have called attention to the large amounts of pumice found high on shingle beaches and other places well above the range of the waves. Here, again, we probably have evidence of this same recent eustatic movement. Although no specific instances were recorded, the writer often noticed pumice in places where it would be difficult for waves to carry it at the present time.

8. *Cliffing*

The formation of cliffs presents some interesting problems in the Barrier Region. As has been shown, the great width of the lagoon and the strong weather so often experienced in it, are responsible for a very fair amount of cliffing. But cliffs are by no means universal features on the islands and mainland, and sometimes they occur where little expected while, conversely, they are often absent where conditions would seem to favour their formation.

It is almost impossible to give any generalization on this question. It is, however, a fact that true cliffs are conspicuous rather by their absence on granite capes and islands, but exceptions can be found at once, as, for example, at Cape Upstart (see Plate, No. 12), where there are some prominent cliffs. Certainly this is an exposed cape, and the Barrier is far away, thus allowing big seas to attack the headland. For the most part the granitic islands and capes are uncliffed. As many of the more prominent headlands on the mainland are of granite, this becomes rather a striking fact. It is not easy of explanation, but a good deal seems to depend upon the type of weathering of the

*Various features in Magnetic Island may be thus explained. See also Andrews's paper just referred to, esp. Palm Islands.

†Reps. Gt. Barrier Reef Comm., vol. 2, 1928, pp. 1–51.

rocks. In nearly all the cases we saw, granite islands and capes weather either into large rounded masses or show exfoliation processes very clearly. The highest development of the former process is seen near Cape Melville. The description of this cape given in the Australian Pilot, vol. 4, is pertinent and almost naïve, but nevertheless very realistic. "This singular promontory is remarkable for the heaps of immense blocks of granite strewed over it, some of which look as if they had been thrown into the sea, forming a continuous border of foul ground, with rocks above water from Rocky point islet to the extremity of the Cape, . . ." This is probably the most interesting headland on the coast. But the same features, on a much reduced scale, are observable on many of the granite shores. They are nearly all bordered by immense rounded blocks. It seems that the tendency to spheroidal weathering as a result of large-scale cuboidal jointing is sometimes so strong that the rock is unable to withstand the attack of the sea sufficiently long to form even a small cliff before these great rounded masses fall down and fringe the shore, thus making a natural bulwark against the breakers, and hindering any further tendency to cliffing.

On the other hand, in sedimentary and metamorphic rocks, cliffs are by no means rare. On account of the recent upward movement which has affected this coast, naturally many such cliffs are slightly raised, and the sea is now attacking any benches which may exist at their foot. Cape Flattery, at the back of its bench, shows excellent cliffing, and so does Cape Upstart.

What has been said of the capes on the mainland applies also to the islands. As can be seen from the photograph (No. 2, opp. p. 244), Dunk Island is uncliffed. The Family Group, Curaçoa in the Palm Group, and others are similar. There may, of course, be minor bluffs formed: Stanley* describes many in the Whitsunday group, some of which were seen on this expedition. But in islands formed of rocks other than granite, cliffs are common. The Frankland Islands, partly gneissic, are good examples. There are many others —we may note many of those between Gloucester Island and the Whitsunday Passage. Flinders Islands, formed of Jurassic sandstone, show well-marked benches and cliffs. It is, of course, precisely in those places where benches are formed that cliffs also occur. And, although there are exceptions, benches are more common on non-granitic shores.

The degree of cliffing is never very great. As Davis† has shown, the absence of cliffs in a reef-enclosed shore is a feature which strongly points to subsidence concurrent with reef upgrowth. A study of the Barrier region fully bears out this point. The width of the lagoon seas is often considerable, and the waves generated within them are fully capable of forming what cliffs are found there. But these cliffs are not those of an open ocean coast. Again, as Davis and others have pointed out, and as has been seen by the present writer, the cliffed coast in parts of New South Wales is a totally different matter. Here the full force of the Pacific is unrestrained by reefs and, dependent on tectonic structure, great stretches of coast are cliffed. Such a feature does not occur within the Barrier: there are cliffs, but they are of no great height, nor do they extend along considerable stretches of coast. They are rather

*Reps. Gt. Barrier Reef Comm., vol. 2, 1928, pp. 1 *et seq.*

†'The Coral Reef Problem,' p. 359.

isolated examples, and appear to depend mainly upon rock structures and exposure.

In the narrow seas just to the north of Cape Melville, where the desert sandstone forms the shore, cliffs are common (*e.g.* on Flinders' Islands). Exposed islands such as Holbourne Island are cliffed, but not to a great extent. Stephens' Island, already referred to, is cliffed on the weather and lee sides: here the softness of the composing rock (volcanic tuff) seems the main factor.

It appears, then, that although cliffs occur they are not of such nature as to modify in any way the conclusion reached by Davis: that the reefs grew up as the coast subsided. In this respect our own observations fully accord with those of Davis, but we, as shown later, differ in certain other matters of detail. It cannot be emphasized too much that we have to deal here with a lagoon greater in every respect than that which occurs in any other coral area, and, as a consequence, the waves in it are able to do much greater work and produce much greater results.

The reader is referred to the photographs of Dunk Island and the coast south of Archer Point, which show clearly how the land slants down in a smooth and unbroken slope below sea-level. These are by no means isolated examples, but the difficulty of photographing features of this sort will be readily appreciated.

9. *The Origin of the Great Barrier Reefs*

(*a*) *Trend Lines in Queensland*

A study of a large-scale map of Queensland shows that trend lines whose directions lie between north-north-west to south-south-east and north-west to south-east are very common. This is seen in many parts of the coast, as, for example, around Rockhampton and Port Curtis, the Whitsunday Group, Hinchinbrook Island, the Frankland Islands, and other places. On the mainland it is seen very clearly in the general direction of the several isolated and short mountain ranges which collectively make up the so-called coastal range. Again, many of the river courses, as, for example, parts of the Fitzroy system and the Brisbane system, also show this same direction. North of Cape Melville a rather different system comes in, the main trends being north to south and east to west.

A good deal has been written about these trend lines, especially by W. H. Bryan,* Sir T. W. E. David,† H. I. Jensen,‡ C. Hedley,§ H. C. Richards,§ and E. C. Andrews.‖ In particular areas, Jardine,¶ in the Port Curtis district, and Stanley** in the Whitsunday district have also demonstrated the occurrence of these same trends. From the present point of view movements of Tertiary and Recent times are the most important, and although consideration should be paid to folding as well as faulting, it is with the latter that we

*Presidential Address, The Royal Society of Queensland, 1925.

†*J. and Proc. Roy. Soc. N.S.W.*, vol. 45, 1911, Presidential Address.

‡*Proc. Roy. Soc. Qld.*, vol. 23, 1911.

§Reps. Gt. Barrier Reef Comm., vol. 1, 1925, p. 1.

‖*J. and Proc. Roy. Soc. N.S.W.*, 1910; and *Proc. Linn. Soc. N.S.W.*, vol. 27, 1902 p. 146.

¶Reps. Gt. Barrier Reef Comm., vol. 1, 1925, pp. 73–110.

**Ibid., vol. 2, 1928, pp. 1–51.

are most concerned. Bryan* summarizes the Tertiary movements, and points out that "faulting mainly along N.N.W. to N.W. lines appears to have taken place in south-eastern Queensland in early times. These faults precede the Tertiary volcanic series, and are therefore only indirectly involved in the present arrangement of the geographic features," and "a later system of faulting has been described mainly on physiographical evidence. This appears to have been confined to the coastal region and to be more marked in those portions where the edge of the Continental shelf closely approaches, and is parallel to, the present coast-line. This faulting post-dated the volcanic series, and its effects are seen *directly* reflected in the coast topography. Hence it must have been very recent."

It may be useful here to mention some of the faults about which Australian geologists are in tolerable agreement. The following are taken from a table given by Andrews.†

Name of Fault System.	*Locality.*	*Uplift Senkungsfeld or Downthrow.*	*Amount of Vertical Displacement.*	*Remarks.*
Bellenden Ker	North Queensland	Uplift Block	Very large	An element of the great N. Queensland coastal scarp. A mountain 5000 feet high here presents a precipitous scarp to the coastal plain.
North Queensland scarp	Lucinda Point to north of Cooktown (250 miles)	Uplift	Very large	This may be partly due to flexing.
Darling Downs Faults	South-Eastern Queensland	All	Some very large	Under examination.
Mount Elliot	Near Townsville, Queensland	Uplift	Large	See W. G. Poole, *Aust. Ass. Adv. Sci.*, 1909.
Macpherson Range	Boundary of N.S.W. and Queensland	Uplift	Very large	Not examined in detail.

These faults and others have been commented on by E. O. Marks,‡ who points out that their authenticity does not depend on absolutely undoubted evidence, but, as has been noticed by Bryan, physiographic evidence alone (as apart from detailed field geology) is almost certainly sufficient to demonstrate them. We shall have occasion to refer to these fault systems later on.

Since Andrews wrote his important papers§ a good deal more detailed work has been done on certain of the coastal regions of Queensland. Stanley, as noted on p. 247, summarizes the build of the Cumberland Islands, and goes on to say: "This systematic arrangement of the physiographical units suggests the operation of a broad control. The writer suggests that fracturing best explains the observed facts, and that morphologically the area consists of a series of fault blocks."

Proc. Roy. Soc. Qld., 1925, Pres. Address.
†*J. and Proc. Roy. Soc. N.S.W.*, 1910.
‡Pres. Address, *Proc. Roy. Soc. Qld.*, 1924.
§*Proc. Linn. Soc. N.S.W.*, vol. 28, 1902; and *J. and Proc. Roy. Soc. N.S.W.*, 1910.

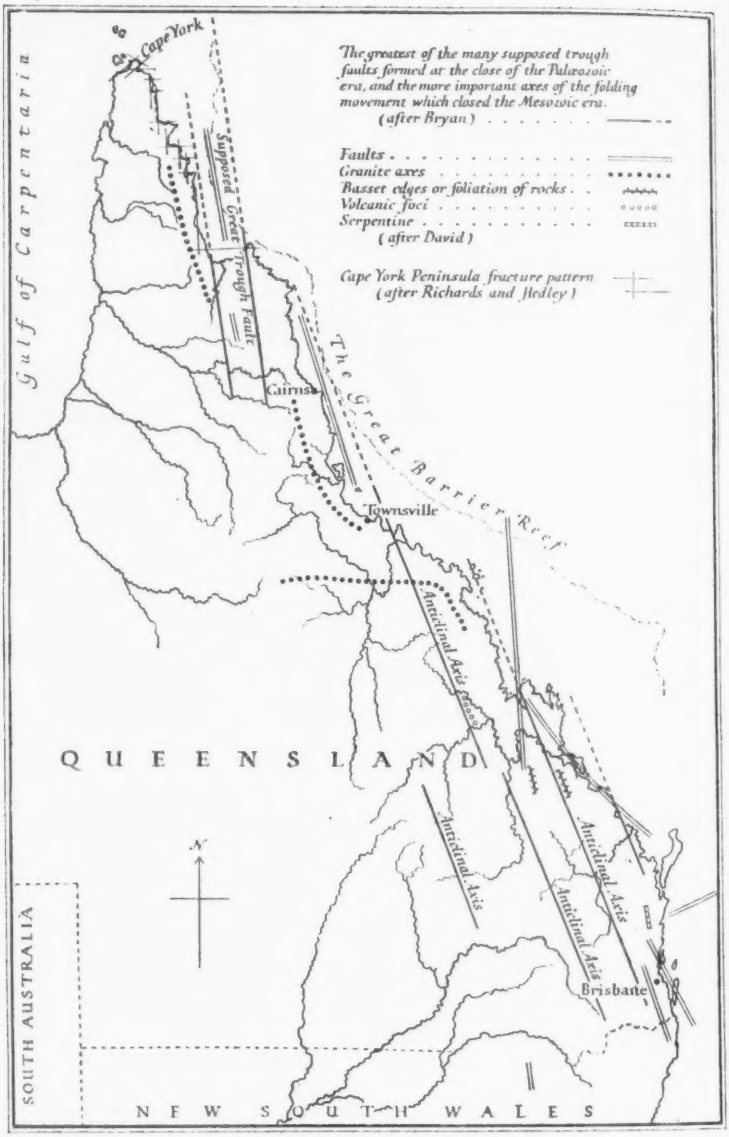


Fig. 7. Tectonic lines in Queensland

(After W. H. Bryan, Sir Edgeworth David, H. C. Richards, and C. Hedley)

Jardine's paper on the Port Curtis district contains a good deal of material illustrating this general north-west to north-north-west direction, which he illustrates in a map of the Islands of Keppel Bay. Further, a series of four cross-sections all show that he has in mind the idea of faulting practically parallel with the present coast-line. The faults in these sections are usually marked with a question mark, but on physiographical evidence he appears to think that they best explain the existing coastal topography (see Fig. 1, p. 235).

David,* in a paper on the Tectonic Features of Australia and Tasmania, published in 1911, calls attention to some very important fault lines in Queensland, which are shown very clearly in a map there reproduced. He refers to the Curtis faulting already noted above by Jardine, and also to an important fault running from Hinchinbrook Island northwards past Cairns up to Cooktown, and beyond. He also associates the southern part of the Cape York Peninsula and the Princess Charlotte Bay area with the faults of the Little River Coalfield.

Enough has been said to make it clear that Australian geologists are in general agreement as to the probability of the existence of a number of north-west to north-north-west fault lines more or less parallel to the present coast, but before closing this part of the discussion reference must be made to the work of Richards and Hedley† in the Cape York Peninsula. North of Cape Melville the coast shows a series of roughly north-south stretches alternating with shorter east-west stretches. The changes of direction are in each case marked by a prominent headland, *e.g.* Cape Direction, Cape Weymouth, Fair Cape, Cape Grenville and Orford Ness, and the writers refer to W. H. Hobbs, who has pointed out that such a fracture pattern is common to many parts of the world. In the extreme north, in the islands of Cape York and Torres Strait, the more important fracture lines appear to run north-east to south-west, and north-west to south-east.

Finally, it may be noted that the same trends also appear in lines of serpentine and other rocks (*e.g.* near Gympie).

We shall discuss the significance of these trend-lines in a later section.

9. (*b*) *The Continental Shelf of Eastern Australia*

The main facts concerning the Queensland shelf have been well summarized by Bryan,‡ who notes four main characteristics: (1) The edge of the shelf is more than usually clearly defined; (2) it supports the greatest known reef area in the world; (3) the edge of the shelf is by no means parallel with the adjacent coast-line; (4) it varies greatly in width. In other parts of the world the edge of the continental shelf frequently runs nearly parallel with the mainland, and this is so in New South Wales, but not in Queensland except in the extreme south and again between, approximately, Innisfail and Lizard Island. The width of the shelf varies between 15 and 160 miles, and is narrowest near Cape Melville and is widest near Cape Manifold. Allusion has already been made to the prevailing trend-lines in Queensland, and, as in the Whitsunday Islands and Port Curtis district, these trends have been shown to be

**J. and Proc. Roy. Soc. N.S.W.*, vol. 45, 1911.

†Reps. Gt. Barrier Reef Comm., vol. 1, 1925, p. 1.

‡'The Queensland Continental Shelf,' Reps. Gt. Barrier Reef Comm., vol. 2, 1928, pp. 58–69.

characteristic of the shelf as well as the mainland. Apart from this, there are certain other features on the shelf showing the same direction. In the south is the Capricorn Channel, which commences as an embayment in the 100-fathom line and continues as a marked north-westerly depression in the 35-fathom contour. Other features, *e.g.* the Hinchinbrook Channel, and the Capricorn and Bunker Islands, also show this same direction.

In the past a good deal of discussion has arisen with regard to the major openings through the reef, which various writers (*e.g.* Saville Kent) have attempted to correlate with existing rivers. The major openings however, such as Trinity Opening, Flinders Passage and others, are not obviously connected with any existing rivers. From what has been said already, it will be clear that we shall not be far wrong in assuming that before the submergence of this shelf the rivers which then flowed on it probably showed the usual sub-meridional trends. This point has been noted by Richards,* Hedley,† Bryan‡ and others; and Hedley has suggested the possible connection of the Russell-Mulgrave Valley with Trinity Opening off Cairns, whilst Jardine§ connects the narrows of Port Curtis with Curtis Channel to the south.

That any definite connecting line between reef openings and rivers cannot now be shown to exist is only to be expected, since there is reason to believe that a good deal of sedimentation has occurred on this submerged shelf which would necessarily obliterate any former river channels.

The many cross-sections of the lagoon which have been published, and the detailed nature of the Admiralty Charts, clearly show that the lagoon floor is a slightly undulating plain which is covered by about 200 feet of water. From this plain rise innumerable reefs and islands.

An examination of the Admiralty Charts shows that the continental shelves of Queensland and New South Wales are continuous, and this is a point on which many writers on the Barrier Reef have commented, and it has led naturally to the suggestion that the reef is merely a veneer of coral built up on the shelf in those parts where conditions of temperature and so on are favourable to coral growth. It is probable that conditions are more complex than this.

It was first pointed out by Hedley‖ that where the outer edge of the shelf is near to the mainland coast the Pacific watershed is also nearer to the coast, and conversely. Bryan¶ has argued that the true edge of a continent should be taken, not at the present coast-line, but at the edge of the continental shelf; that is, roughly, at the 100-fathom contour. If this is so, the Queensland coast, qua coast, cannot be considered as very significant, but, as he says, "the details of its indentations should, of course, reflect the geological trends of the state."

**Queensland Geogr. J.*, vols. 36 and 37, "Problems of the Great Barrier Reef."

†*Trans. Roy. Geog. Soc. Qld.*, vol. 1, p. 69; and Reps. Gt. Barrier Reef Comm., vol. 1, 1925, p. 69

‡Reps. Gt. Barrier Reef Comm., vol. 2, 1928, p. 64.

§*Trans. Roy. Geog. Soc. Qld.*, vol. 1, p. 105; and Reps. Gt. Barrier Reef Comm., vol. 1, 1925, p. 105.

‖*Proc. Linn. Soc. N.S.W.*, 1911, p. 37.

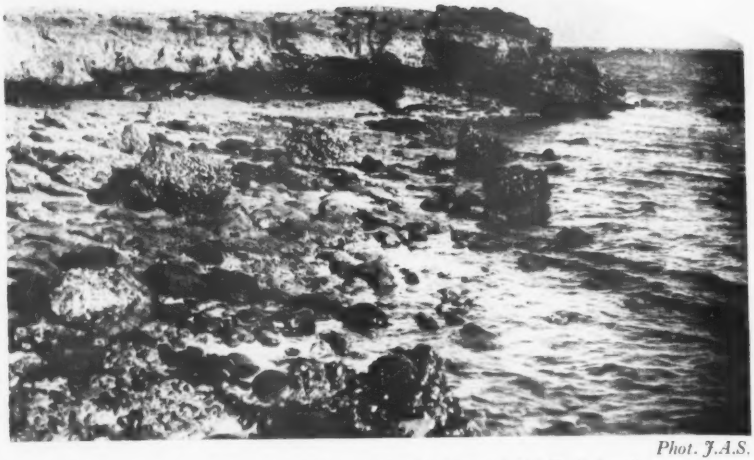
¶Reps. Gt. Barrier Reef Comm., 1928, vol. 2, p. 58.

Phot. J.A.S.

8. Low level platform and cliffs near Sydney, New South Wales

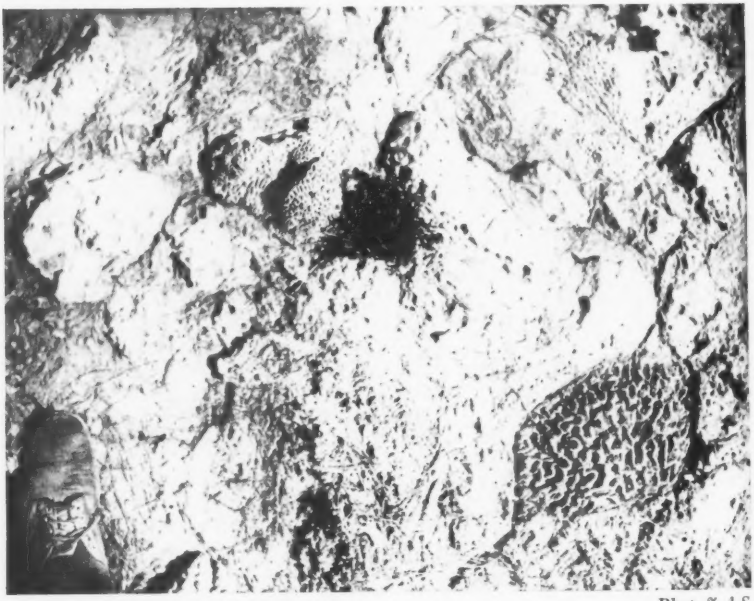
Phot. M.A.S.

9. Archer Point: minor bluffs



Phot. J.A.S.

10. *Uplifted conglomerate platform, Middle Island*



Phot. J.A.S.

11. *Coral conglomerate of upraised platform, Houghton Island*

It may not be irrelevant to note here the undesirable name "Great Dividing Range," which appears on so many maps. Griffith Taylor* some years ago pointed out that it is not a range at all and that it does not form a geological entity. In fact, at best it may be said to form the western edge of the eastern highlands. On the other hand, the many ranges near the coast, each bearing a different name but collectively called the coastal ranges, may, Bryan† thinks, form a unit of some significance. They nearly all show the characteristic Queensland trend. As noted above, Hedley‡ pointed out the relationships of the 100-fathom line and the Pacific watershed to the present coast-line. Bryan holds that neither the "Great Dividing Range" nor the present coast-line have any real significance, but suggests that if Hedley's views are reworded to read "the western edge of the highlands and the eastern edge of the continental platform are symmetrical about the axis of the coast ranges," they may indicate a point of some interest inasmuch as the coast-line and the coastal ranges are not far apart, and also because Griffith Taylor§ concluded from a study of the Queensland river system that the main watershed prior to that now existing was probably where the coastal ranges are now found. In brief, Bryan's‖ hypothesis is: "If the coastal ranges form the remnants of a dominating central axis about which the highland region has been symmetrically formed, then the eastern edge of the continental shelf should mark the original limit of the region of the highlands, and would thus constitute an extremely important structural line and a most likely boundary for a continental mass."

The geological evidence for this is naturally of a rather hypothetical nature, but Bryan has brought together evidence to show that the area now occupied by the eastern highlands, and, as far as can be estimated, the whole of the continental shelf, formed during Palaeozoic and Permo-Carboniferous times a great geosyncline—the Tasman geosyncline. It is probable that the eastern limits of this geosyncline and of the present continental shelf were in close agreement. During Mesozoic times, the sediments thus accumulated were folded along north-north-west axes and formed the "great East Queensland geanticline." It follows, naturally, that on this hypothesis the floor (*i.e.* below recent sediments) of the present lagoon consists of Palaeozoic rocks.

As far as can be seen from the maps in the earlier paper by Bryan,¶ the geosynclinal area continued south of the present political frontier of Queensland, and well down the New South Wales coast. It appears, then, that the continental shelf of New South Wales is geologically similar to that of Queensland.

We must now turn to the views of W. M. Davis** on this shelf. Davis shows, from a study of coral reefs throughout the world, that as a rule barrier reefs, or reefs of any kind, are absent from shelves built of unconsolidated sediments. Further, Davis points out that many observers imply that the Barrier Reef

*'Physiography of Eastern Australia,' Bull. No. 8, Commonwealth Bureau of Meteorology, Melbourne, May 1911.
†Reps. Gt. Barrier Reef Comm., vol. 2, 1928.
‡*Proc. Linn. Soc. N.S.W.*, 1911, p. 37.
§Bull. No. 8, Commonwealth Bureau of Meteorology, 1911.
‖*Op. cit.* and *Proc. Roy. Soc. Qld.*, 1926, p. 93.
¶*Proc. Roy. Soc. Qld.*, 1926, p. 93.
**'The Coral Reef Problem,' 1928, p. 358.

has grown up from a northward extension of the continental shelf of New South Wales.

From a careful reading of Davis's account it seems that he implies that observers who base the Barrier Reef on a northward extension of the New South Wales continental shelf, must at the same time assume that the reef is based on a shelf formed in large part of detritus. Davis quotes R. T. Chamberlin on Tutuila: "In 1902 E. C. Andrews* showed that the foundation on which the Great Barrier Reef of Australia rests does not come to an end with the southern limit of the coralline mass, but continues southward as a submerged platform into the cooler seas, from which he (*i.e.* Andrews) inferred that only a part of the whole structure is formed of coral growth. The coral reefs are perched upon a flat shelf resulting apparently from marine planation in part, and in part from the submergence of a coastal plain."

Davis criticizes this in two respects: (1) He thinks the first sentence overstates Andrews's views; (2) The last sentence goes too far in presenting the results as demonstrated conclusions. He goes on to say: "Indeed, no compelling reasons are given by Andrews for believing that the organic barrier of the Queensland coast is based upon an inorganic detrital shelf."

It appears that Davis holds that a detrital shelf is a foundation unsuitable for coral growth—but does it follow that the whole East Australian shelf is of this nature? Further, writers who hold that the coral reef is a veneer on this shelf do not at the same time necessarily imply that it is a detrital shelf.

This leads on to another and very important point of Davis's. As will be more fully discussed later, a coral reef growing up during subsidence of a land mass will normally form a protective agent, and so islands and promontories within the upgrowing barrier will be non-cliffed or, in the case of a barrier, such as that of Queensland, a long way from the mainland, the cliffing will only be such as could be brought about by the lagoon waves.

Now, from an inspection of any good map, a strong contrast will be found to exist between the coastal features of Queensland and New South Wales. The former is island ridden and typically non-cliffed, the latter has few islands, usually tied to the mainland, and many miles of cliffed shore. Consequently Davis concludes that the Queensland shore demonstrates subsidence during reef upgrowth, but the New South Wales shore, to him, contradicts this view. He admits, however, that the New South Wales shore may never have had so many islands as is the case in Queensland. Those islands which did exist have been completely abraded away by wave action. Thus his general conclusion: "I find it impossible to accept the idea that the Great Barrier Reef of Queensland has been recently built up from a continental shelf of unconsolidated sediments that was prepared, previous to reef establishment and upgrowth, under conditions such as still prevail on the coast of New South Wales."

But this conclusion implies that the apparently continuous continental shelf of East Australia is of dual origin, and this Davis admits. "But in any case, the independent development of a great barrier reef by organic processes in the warmer waters and of a great continental shelf by inorganic processes in the cooler waters of the same sea is eminently possible. Indeed, had torrid Queensland been separated by a strait from temperate New South Wales, the

Proc. Linn. Soc. N.S.W., vol. 27, pp. 147–185.

independent development of the organic reef off the torrid coast, and of the inorganic shelf off the temperate coast might never have been doubted."

There is no reasonable doubt that Davis's conclusion, in so far as islands and cliffs are concerned, is right—that is to say, the preservation of islands and small amount of cliffing on the Queensland shore is the direct outcome of reef protection.

But, at the same time, it seems highly probable that the whole continental shelf of Eastern Australia is an entity, though we may admit that some parts have been affected by special conditions which are discussed later. There is also little doubt that the Barrier Reefs have been formed in a subsiding area and that they are best explained by slight modifications of the Darwinian hypothesis. Some writers, as, for example, Agassiz* and apparently Guppy,† have suggested that the shelf is largely a feature of marine erosion. This view, in such a simple form, may probably be dismissed as untenable. Others, such as Daly,‡ and now apparently Andrews, associate the shelf to some extent with the lower sea-level of glacial times, but Daly at any rate is at pains to point out that there is no reason to believe that the entire shelf was formed by wave benching in that period.

Vaughan§ tends to follow Andrews in his general interpretation. A fuller description of Andrews's earlier views is given below in the discussion of the origin of the Barrier.

9. (*c*) *On the Origin of the Great Barrier Reefs*

In the two preceding sections a discussion has been given on the trend-lines of Queensland and on the nature of the continental shelf of Eastern Australia. It is a commonplace that the origin of the reef really resolves itself into a question of the origin of the platform on which it stands and, as noted earlier, several writers have assumed that the reef is merely a thin layer of coral, somewhere about 200 feet thick, resting on the northern end of this platform. W. M. Davis‖ called attention to two points which this view cannot explain. Some writers seem to have assumed that the reef was formed after the shelf, and this in turn implies an explanation for the long delay before the reef established itself or for the establishment of the reef after the long delay. In other words, they appear to assume that the origin of the reef and the shelf are entirely independent. We shall have occasion to refer to this point later.

In our cruise in Barrier Reef waters we were greatly struck by many features which seemed best explained by faulting. The narrow Hinchinbrook channel, running between that island and the mainland, is bordered for part of its course on its eastern side by a smooth-faced and almost vertical cliff, which might possibly be the wall of a deep canyon, but, on the other hand, is reasonably explained by faulting. Farther north, especially between Cairns and Cooktown, the mainland coast is for the most part steep and usually uncliffed,

**Bull. Mus. Comp. Zoo. Harvard*, vol. 28, No. 4 (Geol. Ser. vol. 3).

†*Victoria Inst. J.*, vol. 23, 1890, pp. 46–71.

‡*Amer. Acad. Arts and Sci.*, vol. 51, 1915, p. 197, and other papers.

§*Bull. Geol. Soc. Am.*, vol. 27, 1916, pp. 41–45; *Am. J. Sci.*, Ser. 4, vol. 41, 1916, pp. 131–135; *U.S. Nat. Mus. Bull.*, No. 103, 1919, pp. 189–524.

‖'The Coral Reef Problem,' p. 358.

except for minor bluffs such as could be produced by lagoon waves. Physiographically it bears every resemblance to a typical fault coast. Again, the river systems of that part show indisputable evidence of recent vertical movement on a large scale. This is well shown by the Barron river on which various writers, including Hedley and Taylor* and Danes,† have commented. The Pacific watershed here is very close to the coast, and the rivers flowing to the lagoon have cut steep and narrow gorges of which that of the Barron is the best known. Hedley and Taylor have shown that it is highly probable that the Barron has captured the headwaters of the Mitchell, which river flows into the Gulf of Carpentaria. There is little doubt that we have to deal with great vertical uplifts in this part, and that the lower courses of these rivers have been truncated and now lie beneath the lagoon. Danes, commenting on the Barron river, wrote:

"La puissance d'érosion et de transport des fleuves et des torrents, dans cette contrée pluvieuse et de relief si abrupt, est réellement prodigieuse, et il est difficile d'en exagérer l'importance. A mon avis, la profondeur des détroits entre le continent et les récifs coralliens a été jadis très considérable, et ce sont les alluvions continentales, étalées d'une façon très régulière par les marées et les courants, qui ont adouci et uniformisé le relief.

"La très grande fraîcheur des formes du terrain dans la chaîne côtière et dans les massifs granitique du Bellenden Ker et du Bartle Frere, l'existence paradoxale d'une ligne de partage des eaux sur le bord de la muraille côtière, l'excessive jeunesse des vallées fluviales, d'une part; et, d'autre part, en opposition avec tout cela, les formes très anciennes et même séniles de l'arrière-pays,—voilà autant des preuves éclatantes que les grandes transformations tectoniques qui ont déterminé le tracé et l'aspect de la côte actuelle sont d'âge relativement très récent. Or les observations faites dans la région de Cooktown (par L. Ball), sur la Burdekin R. (par W. Poole), la Herbert R. et la Tully R., fournissent autant de témoinages dans le même sens. Ainsi les anciennes conceptions sur l'évolution du Nord-Est australien et de la Grande Barrière se trouvent rectifiées de façon décisive."‡

Another point which strikes the attention of the traveller in these northern parts is that within the Barrier Reef proper there is a broken line of inner reefs running more or less parallel with the mainland and the outer reef proper (see Fig. 2, p. 242). It would be easy to assume that these inner reefs are based on solid foundations, but the recent boring on Michaelmas Cay shows that this is by no means necessarily the case. The results of this boring were rather unexpected. The bore reached a depth of 600 feet. "The log shows that apart from a few feet of solid material the coralline material was loosely coherent, that it extended to a depth of 427 feet, and that beneath this (apart from the little sand recorded from 477 feet) down to a depth of 600 feet there was nothing other than rounded quartz with abundant foraminifera, and shell fragments with much glauconitic material."§ So far as can be seen from this section there is no reason why a reef should not grow on incoherent material.

*_Aust. Ass. Adv. Sci._, Sect. C, 1907, p. 397.

†_Sitzungsberichte d. k. Bohm. G.D. Wissens._, 1911 (Math. Nat. Classes), Prague, 1912 (November paper 4), pp. 18; and _Annales de Géog._, vol. 21, 1912, pp. 346–363.

‡_Annales de Géog._, vol. 21, 1912, pp. 346–363.

§Reps. Gt. Barrier Reef Comm., vol. 2, 1928, p. xii.

Davis,* commenting very briefly on it, has suggested that the quartz sand may represent a former sandspit burying a former reef (*i.e.* in a previous cycle), much as the sands at the southern end of the barrier are encroaching on the coral there.

The site for the bore was chosen after an exhaustive study of the charts, and several visits to likely sites were made before Michaelmas Cay was chosen. On account of the rather unexpected results obtained it is better to leave the matter until a detailed analysis and report of the bore are to hand.

As the origin of the reef appears to be intimately connected with the origin of the platform, it will be relevant here to quote Agassiz, who was a strong believer in the erosion hypothesis. He writes: †

"An examination of the sections along the passes through the Great Barrier Reef shows a very gradual pitch in the continental slope, and there is nothing to indicate that the outer Barrier Reef patches rise from very great ('unfathomable') depths. On the contrary, the outer reef patches are all well within the 100-fathom line, and at a distance from it, except where the pitch of the continental shelf is unusually steep. The inner reef patches all come up from a line, which cannot be of a greater depth, about twenty fathoms, that being the average depth of the first inner channel between the outer patches of the Barrier Reef and the outer line of the inner reef flats. The inner line of reef flats rises from a lesser depth, not more than ten to fifteen fathoms. The section lines passing from the mainland to the line of the outer barrier reef, across high rocky islands and reef flats, indicate that the coral reef rock and coral reefs can only constitute a comparatively thin sheet from the outer line of inner reef flats towards the mainland, and that this sheet probably does not extend beyond the lower slope of the islands which they surround, and the base of which is formed by the submarine extension eastward of the strata of the continental slopes. And furthermore, that the outer barrier reef probably does not rise from a much greater depth than that at which reef-building corals cease to flourish . . .

". . . That such a depression as is required by the Darwinian theory of coral reefs has actually taken place over the greater part of North-Eastern Australia, no geologist will deny. But it is a depression which dates back to the Cretaceous period, and surely we cannot claim that the corals which underlie the Great Barrier Reef of to-day began to grow along the Cretaceous shores of North-Eastern Australia at the time when this great depression began, and that they have a thickness which would correspond to a depression of at least 2000 feet? There is nothing in the known configuration of the coast of Queensland, as shown by the hydrography, to warrant such an inference."

As pointed out by Davis,‡ Agassiz gives no evidence of the existence of such a platform, and Hedley and Taylor§ have shown how difficult it is to assume that ordinary marine erosion could possibly have cut such a platform and leave so many rocky islands on it. Further, when it is realized that the islands and the mainland coast of Queensland are practically uncliffed, it will be seen that little attention need be paid to this theory. Reference has already been

*'The Coral Reef Problem,' p. 357 (footnote); and David, *Quart. J. Geol. Soc. London*, vol. 83, 1927, p. vii.

†*Op. cit.*, p. 141.

‡'The Coral Reef Problem,' p. 348.

§*Aust. Ass. Adv. Sci.*, Sect. C, 1907.

made to Gardiner, Daly, and Vaughan. Davis's views are based very largely on those of Andrews, whose earlier papers are perhaps the most comprehensive of all those written on the Barrier Reefs. However, before discussing Andrews's views, it is relevant to note that Beete Jukes and Saville Kent saw in the Barrier Reefs a simple subsidence such as Darwin postulated in his original work on coral islands. It is curious that Jukes in his well-known section of the Barrier Reef (see Fig. 1, p. 235) took no account of the numerous high rocky islands. It is rather difficult to correlate his written accounts with his section. If he had allowed in his section for the occurrence of one or more such islands, he would almost certainly have had to modify his conception of the thickness of the coral mass.

There is no doubt whatever that we have to deal with submergence on this coast, but it does not seem to be merely a case of a simple sinking of the land and of the building up of first a fringing reef, which, as the land continues to sink, passes into the stage of a barrier reef. Perhaps nowhere else in the world can it be better demonstrated how closely the origin of a reef depends on the tectonic structure of the adjacent land, and in reviewing the main points of Andrews's work it will be helpful to bear in mind what has already been said about the trend-lines and the continental shelf of Queensland.

Andrews has made intensive studies of the New England District in the north of New South Wales,* and also knows much of the reefs from first-hand knowledge, and, in a valuable paper on the Geographical Unity of Eastern Australia in late and post-Tertiary Times,† he summarizes his general views and brings together a great deal of convincing evidence to show that: (1) a peneplain was developed during Eocene and Miocene time, and that this peneplain was formed about sea-level; (2) the Pliocene was partly a period of sedimentation and partly of erosion; (3) the close of the Tertiary period was characterized by the development of great series of faults running more or less parallel to the present coast; (4) the present continental shelf is a portion of this peneplain faulted below sea-level in late Tertiary Time, and later it has been modified by wave erosion and sedimentation; (5) there has been a still later general submergence which may have varied in amount in different parts of the coast: the average amount of this submergence is about 200 feet; (6) there has been a recent, slight, movement of elevation. Much of this evidence depends upon his interpretation of the "leads" or buried river deposits which are contemporaneous with the newer volcanics, which, in their turn, have been shown by von Mueller to be Upper Pliocene. A study of the fossils in these "leads" points to a mild and fairly uniform climate over North-Eastern Australia at that time, and this, in Andrews's view, implies a country of moderate relief. During the time of the formation of the "leads," the floras of Eastern and Inner Australia were similar. This is not the case at the present time. The fact that the late Tertiary floras in these "leads" are the same on either side of the eastern highlands suggests that in the late Tertiary all this part of Australia consisted of an area of moderate relief. At the present time these "leads," and the basalts covering them, are cut through by gorges, such

Recs. Geol. Surv. N.S.W., vol. 7, Pt. 3, 1903, pp. 140–216; and *ibid.*, 1904, vol. 7, Pt. 4, pp. 281–300.

†*J. and Proc. Roy. Soc. N.S.W.*, vol. 44, 1901, p. 420.

as the Barron,* several thousands of feet deep, and these gorges indicate approximately the amount of uplift. This period of faulting is most pronounced in South-Eastern Australia and has received the name of the Kosciusko period of plateau formation; apparently it was a period of comparatively rapid upward movements. Further basaltic flows occurred after this period of faulting, and the eastern portion of the continental shelf appears to have been formed partly by flexing and partly by erosion and sedimentation. It was at this time that Andrews thinks the Barrier Reefs were outlined. At a still later period (*i.e.* the more recent submergence) the coast of Eastern Australia took on its present form with its typical drowned valleys. It was during this later period that Andrews suggests the inner reefs were formed and probably New Guinea and Tasmania were finally isolated. It was then, therefore, that the continental shelf attained to its present dimensions and the Barrier Reefs reached their present form. H. I. Jensen† also seems to be in general accord with Andrews's views.

Davis, in his recent book,‡ appears to have based many of his views about the Barrier Reef on Andrews's work in New England,§ but he seems to have built, as he himself frankly admits, too great a super-structure on this work. Andrews claimed in his original paper that there were in New England three separate peneplains separated by three periods of elevation and erosion. In 1910,‖ however, Andrews wrote: "In a previous paper the writer considered certain levels, such as the Bolivia plain, to be peneplains of two distinct ages. These, however, merely represent faulted and flexed blocks of the late Tertiary peneplain in New England. . . . It would appear to indicate that wherever in Eastern Australia two unrelated plateau masses exist side by side at variable altitudes a fault or fold separates them." This statement apparently modifies very considerably his earlier views on the peneplains of New England, and consequently the foundations of Davis's super-structure are considerably weakened. Davis's latest views are summed up as follows: "My own opinion is that the total submergence of the Queensland border since reefs began to grow there and the total thickness of reef upgrowth from the foundation thus offered on the submerged land border as well as the total thickness of lagoon deposits now included between the down slope of the submerged land and the inner face of the Barrier Reef are all of large measure. In other words, that the reef is as good a witness for Darwin's theory as Jukes took it to be."¶

It will be clear from what has been said above that the present writer thinks that the faulting or flexing of the peneplain has been the dominant factor in the formation of the reef rather than the subsidence of the continent as a whole. Evidence has been brought together to show that faulting has either been actually demonstrated or at least strongly suspected on topographical evidence by several writers, and in many places our own observations in

*This, in itself, merely proves uplift on the land side. It is, however, more than probable that normal faulting of this magnitude would involve considerable downward displacement of the eastern block, relatively, to sea-level.

†*Proc. Roy. Soc. Queensland*, vol. 23, pp. 149–198.

‡'The Coral Reef Problem.'

§*Recs. Geol. Surv. N.S.W.*, vol. 7, Pt. 3, 1903, pp. 140–126.

‖*J. and Proc. Roy. Soc. N.S.W.*, vol. 44, 1910, p. 420.

¶'The Coral Reef Problem,' p. 349.

practically all parts of the reef region have confirmed this. This evidence is so strong as to leave no reasonable doubt that faulting has played a most important part in the formation of the present coast-line. At the same time, however, reasons have been given for believing that the faulting has been more intense in the northern* and north central parts of the Barrier area. Further, it has been shown that the trend lines of the continental shelf are similar in every respect to those of the mainland. Briefly, the writer's view is that, taken as a whole, the barrier has grown up concurrently with the subsidence of a series of fault blocks.

There are, however, certain difficulties. In the north the evidence seems to be fairly conclusive. In view of the fact that the Michaelmas Cay boring definitely shows that a coral reef can grow up on unconsolidated material, it seems to remove at least part of Davis's objection to coral reefs growing up on unconsolidated sediments, but it does not lend itself to the idea that all of the inner reef patches are based upon solid foundations at comparatively shallow depths. If the faulting, as we have reason to believe, was comparatively rapid, there is some reason for thinking that the fractured peneplain thus brought below sea-level would at first be kept reasonably free from sediments, especially on those parts of it which corresponded with pre-existing ridges. As there is no reason for assuming that this peneplain was an absolutely level surface, we may in turn take it that it possessed ridges showing the characteristic north-north-west trends of Queensland. May it not sometimes have happened that the Barrier first began to grow on these outer ridges? The objection that the barrier is not always just on the outer margin of the shelf may in this way be partially overcome because there is no particular reason for assuming that the outer edge of the sinking peneplain necessarily coincided with a ridge. We might possibly assume that at some little distance inside the outer edge of the subsiding peneplain ridges were present, and on these the barrier grew. But in any case, as Richards and Hedley have pointed out, the Reef, except in the extreme south, is practically coincident with the outer edge of the platform, and further, they show that Vaughan's sections are unfortunate in their selection.†

In the south, although Stanley and Jardine have shown that faulting has probably played its part, the evidence is certainly not so clear, and it is here that this continental shelf attains a much greater width. But we probably need have little doubt that we are still dealing with this same submerged peneplain, though faulting, such as has been demonstrated in the north, may have played rather a lesser part. It is precisely in this south end that the reefs are much more scattered and stand well within the outer margin of the platform.

It is also true that the Reef is apparently being smothered by sands which are extending northwards. Davis, commenting on this, suggests an explanation which is based on his three-cycle extension of Andrews's work in New England. He writes: "Where a moderate subsidence closed the preceding cycle and introduced the current cycle, the new coral reef may well have been superposed on the earlier coral reef through the major part of the Great Barrier; but in the southern part, where the earlier coral reef had been over-

*Cf. Andrews, *J. and Proc. Roy. Soc. N.S.W.*, 1910.
†Reps. Gt. Barrier Reef Comm., vol. 1, 1925, p. 25.

Phot. M.A.S.

12. Cliffs at Cape Upstart

Phot. M.A.S.

13. Looking south from Cooper Point: residuals and dense mangroves

Phot. M.A.S.

14. Weathering of granite close to Cape Melville

Phot. M.A.S.

15. Uncliffed mainland coast just south of Archer Point

whelmed by sand reefs and where retrogressive abrasion had occurred, the new uppermost reef may have grown up from the cut-back edge of the previous reef. . . ."

For reasons given elsewhere the three-cycle scheme is difficult to maintain, and so the above explanation is open to doubt. In any case, in this southern area conditions are becoming much less favourable to coral growth, and there seems no particular reason why one should expect a reef always to grow up from the outer edge of a platform. It is just possible that these instanding reefs are based on ridges as postulated above. Further, it is in this part of the reef area that one would expect a considerable chilling to have taken place in glacial times, and if reefs existed (as is highly probable) before the Ice Age, may we not suggest that these very southern reefs were wholly or partially killed, and that the present reefs are merely superposed on the old reefs and in places most favourable to coral growth?

Stanley, who worked near the southern part of the reef, states: "Although the conditions demanded by Daly's glacial-control theory are adopted, and the influence of low-level abrasion in producing plunging cliffs is recognized, nevertheless no positive support can be given to the view that the Great Barrier Reef is built on a rock shelf eroded around the margin of the continent by the lowered ocean of the glacial period. The reef is thus regarded as Pleistocene, and probably pre-Glacial in age. During the Glacial Period its growth was inhibited in the north while it was probably destroyed in its southern portion. Its present development is almost entirely post-Glacial." With this we fully agree.

It has been shown, particularly in the north, that there is an inner as well as an outer line of reefs. It is conceivable that these inner reefs may rest on a submerged ridge as suggested in the sections given below (Fig. 8).

The fact that the lagoon floor throughout is of a comparatively uniform depth may probably be ascribed to recent sedimentation,* though it should be remembered that we have little direct evidence for it. There is a large amount of silt in the inshore waters, and in the wet season the Queensland rivers bring down large quantities of solid material. Any former irregularities of the submerged peneplain surface could easily have been smoothed out in this way, and if we are right in assuming that faulting has played a greater part in the north, possibly throwing down the fractured peneplain to greater depths, the fact that the barrier is here so much closer to the mainland would probably largely account for the further fact that the lagoon floor is not noticeably deeper here than farther south. It may be worth while remarking that even in this comparatively silt-laden water thriving reefs exist, and that there are patches of fringing reefs actually along the mainland. The upper surfaces of these fringing reefs are often dead, but this is explained by the recent slight uplift which was discussed in an earlier section of this paper.

The writer's views on the origin of the Barrier Reef can best be expressed in the two following sections and their accompanying notes:

*It is also possible that coral growths have helped greatly in this respect.

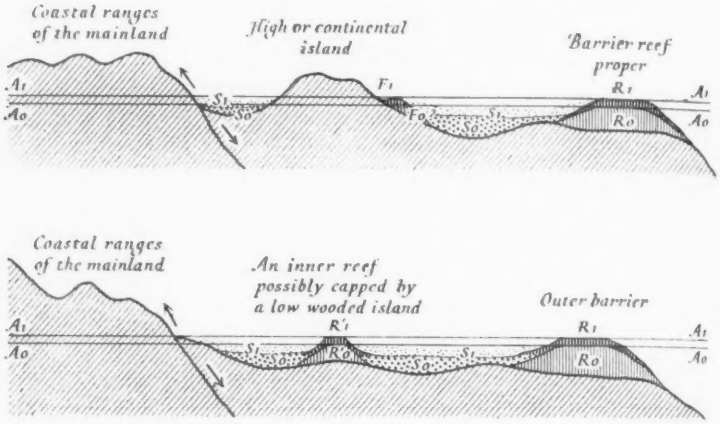


Fig. 8

A_0–A_0 *Supposed sea-level relative to mainland and downthrown area after late Tertiary faulting.*
A_1–A_1 *Supposed sea-level after the later submergence of about 200 feet.*
R_0 *Outer barrier corresponding to sea-level at* A_0.
R'_0 *An inner reef patch corresponding to sea-level at* A_0.
R_1 *Outer barrier after the later submergence.*
R'_1 *An inner reef patch after the later submergence.*
F_0? *A fringing reef corresponding to sea-level at* A_0–A_0.
F_1 *A fringing reef corresponding to sea-level at* A_1–A_1.
S_0 *Recent lagoon sediments accumulated whilst sea-level was at* A_0–A_0.
S_1 *Sediments accumulated since the recent submergence.*
The arrows indicate the directions of movement along the fault-plane.
A_0–A_0 *to* A_1–A_1 *is of the order of 200 feet.*

1. It should be noted that no actual breaks need be assumed between R_0 and R_1, S_0 and S_1, etc.: differences in shading have been used in the diagram merely to bring out the effects of the two movements.

2. The supposed ridge under R'_0 has been drawn at more than 600 feet below *present* sea-level to conform with the evidence of the Michaelmas Cay boring. It is, however, not unfair to assume that in places it is at considerably lesser depths.

3. The submerged peneplain is regarded as having a slightly undulating surface, and, consequently, parts of it may be more deeply submerged than is suggested in the sections.

4. Only one fault is shown: there is no reason why others should not occur, but the essential parts of the scheme outlined would not be altered if they were shown.

5. On account of the amount of land-derived sediment in the water, fringing reefs are rare along the mainland coast, hence none is shown in the sections.

6. Steep talus slopes are possible for the Outer Barrier.

7. In some cases mangrove-shingle cays are found on the inner reef patches.

8. It is easy to conceive of conditions giving rise to more than one inner reef patch such as is shown in the second section. In the same way more than one continental island may be passed through by any straight section drawn at right angles to the mainland coast.

9. The scale of the section does not allow the recent and slight movements of emergence to be shown.

10. The vertical distance between the lines A_0—A_0 and A_1—A_1 is *of the order of* 200 feet. The depth of the lagoon floor below the line A_0—A_0 may be greater than suggested, but there is little direct evidence on this point. It is, however, probable that the submerged peneplain has a tilt toward the Pacific, and if so, the Outer Barrier may be thicker than shown.

11. In some cases the inner reefs (R'_1) may have started to grow when the sea-level was at A_0—A_0, as shown in the second section. In other cases these inner reefs may possibly date back only to the recent submergence (cf. Andrews, 1910). It should be remembered that the material underlying these reefs (and perhaps the Outer Barrier too?) is not necessarily coral in position of growth. (See note on Michaelmas Cay Boring, p. 360.)

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: Mr. J. A. Steers, who is to address us to-night, is a Fellow of St. Catharine's College, Cambridge, and lecturer in the School of Geography in that University under Mr. Debenham. I understand that he obtained from the University a term's leave to go out to the Great Barrier Reef Expedition. That expedition was originally essentially biological. The initiative came from this country, and I suppose we may say that Cambridge was the starting-point. A committee under Sir Matthew Nathan, who is with us to-night, helped to organize the expedition, and a committee in Australia, in cooperation with the British committee, carried out the local work. Although I have just remarked that that expedition was essentially biological, I am not saying that biology is not, in certain aspects, much the same as geography, because I am quite prepared to claim the whole of biology, if necessary, as a branch of our subject. This Society thought that we should take advantage of the expedition going to the Great Barrier Reef to attach certain geographers, and amongst them we attached Mr. Steers, who is with us to-night, and Mr. Spender of Balliol College, Oxford, who is still on the Reef and going on with his work. Mr. Steers had to come back to his duties in England, and spent only a few months on the Reef. We are anxious to hear how the geography of the Reef is getting on, and we hope we shall not trench too much on the biological side; but, if we do, we still claim that there is a biological side to geography.

Mr. Steers then read an abstract of the paper printed above, and a discussion followed.

The PRESIDENT: We have with us Sir Matthew Nathan, who was Chairman of the British Great Barrier Reef Committee, was largely responsible for the despatch of the expedition, and is a former Governor of Queensland. We shall be glad if he will begin the discussion.

Sir MATTHEW NATHAN: First of all, I have to deny that I am responsible for the expedition that is now on the Great Barrier Reef. Some seven years ago the need for further investigation of the various problems of the Reef was pointed out by Professor Richards, the professor of geology at the Queensland University, to whom Mr. Steers has referred. After a lecture he gave on the subject at a meeting of the Royal Geographical Society of Australasia in Queensland, some of us came together and decided that steps should be taken to secure a more continuous investigation of the Reef than had hitherto been carried out. A committee was formed and has during the past seven years done much research work, largely geological and physiographical. It was recognized by the committee there that they had neither the means nor the men able at the time to do the corresponding biological work. This was pointed out about three years ago

to the professor of zoology at Cambridge, and it was then decided that, if the Queensland committee wished it, a biological expedition should be sent out from this country. This was done, and our President explained at the commencement of this evening's proceedings how geographical specialists came to be attached to the expedition. That they were so attached has been a great benefit, as you have had evidenced to you this evening by the interesting remarks of Mr. Steers.

I do not know that I want to say anything with regard to those remarks, except to express my gratitude for the lecture, and that gratitude takes the usual form of a keen sense of favours to come. He has described with greater amplitude than that of any previous description the many islands along the coast. At the conclusion of his remarks he referred to the various theories of subsidence and elevation according to which the continental shelf has had imposed upon it the coral of the Great Barrier Reef of Australia. We expect later on to have some development of those theories and new light thrown on them by the studies that Mr. Steers has begun and which, I understand, he intends to continue.

There are one or two minor points on which I should like to ask questions. I am not quite sure whether the beach rock he spoke about is coral conglomerate, formed of coral shingle exposed to weather for some time, or whether it is the natural surface of the dead coral rock. I should also like to ask whether those blocks of coral called nigger-heads are, in his experience, always found on the windward side of the coral cays. I have seen it stated that, at any rate in the northern part of the Reef, they are generally on the leeward side, that being the direction from which the cyclones come and cause the big seas that break off masses of the coral and throw them on to the land already formed. One last, and possibly more difficult, question I should like to ask, and that is whether Mr. Steers could give any indication to us of the areas on which the two elevations to which he referred have operated, whether there is evidence of any continuous parts of the ocean bed being raised at those different periods of elevation. I will not go into further details, but would say, in conclusion, that I think the lecture has been a very useful one. I certainly have learned a great deal on a subject to which I brought a fair amount of ignorance to bear.

Professor J. STANLEY GARDINER: I should be ungrateful if I did not first express the indebtedness of the biologists concerned with the Great Barrier Reef expedition to the Royal Geographical Society. The expedition as arranged was biological, but it was soon understood that the organisms building up this great coral reef had not only to be studied for themselves but in relation to many environmental factors. It was essential that some geographers should go out to work in relationship with the biologists, who could not do their work without a referee in this country, to whom they could refer their geographical problems. The committee had no money. The Royal Geographical Society came forward and paid all the expenses, and I think every biologist in this country and on the committee is intensely grateful to the Society for their public-spirited action in this matter.

We must all feel greatly indebted to Mr. Steers for the extraordinarily lucid description he has given us of the areas he visited. He went to a reef; he travelled along it, 800 miles or so; he found 800 different problems, a problem per mile; and yet he concentrated on a few, exercising judgment, and these he has presented to us. We trust that at a later meeting he will present his conclusions on some of these other problems. Perhaps at an afternoon meeting of the Society, when probably there will be considerable controversy; at an evening meeting when there will be presented the conclusions of the whole inquiry.

Now, this Reef to me is entirely different from any reef I have ever seen either in the Indian or in the Pacific Oceans. I think I might point out one or two of

these differences. In the first place, the inner islands are covered with mangroves; and Mr. Steers showed us beautiful photographs of young mangrove plants which had traversed 10, 20 or 30 miles of sea, coming to anchor and building up sand into land. Another point is that these islands with their shingle rock are situated within the lagoon, whereas it is generally characteristic of the rocky islands that they lie on the outer side of the encircling reefs close against the breakers of the open ocean. I do not think I go too far in saying that in the only group of islands comparable with this in size, the Maldives, 700 miles or so long, there is not a single island in any lagoon with shingle rock such as Mr. Steers describes, and there is not a single atoll which has not portions of the encircling reef with the shingle rock near the open ocean. The beach sandstone, according to the photographs Mr. Steers showed, slopes in the reverse direction to that usually taken, viz. the slope of the beach to the water. It is quite possible that what we call and what he calls by this name may really be a different structure altogether, and this can only be revealed by close examination of actual specimens.

With regard to the low 10-foot platform of which Mr. Steers spoke, I do wish most sincerely that he would not pledge himself beforehand by talking about elevation or subsidence here. Why not use the terms positive and negative movements of the water? This platform may be due to movements of the Earth's crust, or of the water in respect to the land. Most of us believe that this shelf that Mr. Steers speaks of as a double shelf—this is not usual elsewhere—is due to the drawing of water away from the equatorial regions towards the Poles. It is a structure that is found on nearly every reef. It is usually a little higher under the Equator than in higher latitudes, but it is certainly not due to any change in the crust of the Earth, unless we are going to assume a change which runs to 30° north and to 30° south latitudes and all round the centre of the world, a distortion of a few feet.

Then again I would venture to mention the theory of Daly, which has not been referred to to-night, in which he supposes that during the late part of the Tertiary period there was a withdrawal of water from round the Equator to form the ice-caps of the Polar regions, which withdrawal of water meant a negative movement of 300 feet or so. The central parts of the oceans would have been cooled down very materially, and that cooling at Cairns, which I think is 16° south lat., would have been felt sufficiently to have destroyed its reefs. Daly supposes that there would then have been great platforms cut at the edge of the continent which subsequently would have given foundations for the corals and for the plants which in association built up the present reefs as the water returned while the ice melted. Most people scarcely think that this theory is well founded. Next Davis, who has been referred to, points to the Queensland coast as against the coast of New South Wales and Victoria as being different, since it has many islets of different sorts whereas the southern coast is almost devoid of islets; at any rate, we have to account for this coast somehow or other.

I would venture to point out to you the extraordinary difference that there is in this 1400 miles of coast from any coasts to the south or that we get in the North Atlantic. Every coast that we get here is washing away. We have material carried farther and farther to seaward; we have a good deal of that material passing into solution or suspension in sea-water, and being distributed to great distances. These coasts in the Atlantic are lines of lightening of the earth's crust, and off India the story is the same. Here you have something different: a coast where weight after weight is being added to its line, for these reef plants and animals are very much heavier than sea-water, and these additions are continuous, day by day and year by year. We estimate the extent of the

weight that is added or lost, and some of us venture to think that the solution of a good many of our island problems lies here. We know that any alteration of weight must be felt, to some degree, by the earth's crust, and we are coming more and more to the conclusion that we, who have worked on these problems, are in the hands of the geodesists rather than in those of any other branch of geography.

Dr. G. P. BIDDER: I should like, first of all, cordially to second what Professor Gardiner has said as to our indebtedness to the Royal Geographical Society for helping us biologists by sending out this valuable geographical mission. In the case of such an expedition, if you have first one science represented, such as zoology, and then add another such as botany, then add a third such as chemistry and a fourth such as physics, and then, through the munificence of a great Society like this, a fifth, a master science such as geography—you do not merely have five times the value of the observations which you would have had with only one science represented, but you have something like, say, twenty-five times the value in the work; because every one of those five sciences reacts on the other, and the observations made by each man are so much the more valuable for the presence of each of the four other men. We have made a certain amount of zoological observation for which it was absolutely necessary that contemporary botanical observation should be made, and if these were to be interpreted it was necessary that the most exact observations should be made of the chemical constitution of the sea-water, observations that required a skilled expert, and then there had to be recorded the physical condition of the water. Now, the whole of these results have been indexed and placed in position on the world's surface—or, as we are told to-day to say, in position as events in the space-time continuum—by you, sir, and your able representative, Mr. Steers; and we biologists thank you very much.

Mr. J. A. STEERS: There are just one or two questions for me to answer. By beach rock, I really meant the rock found on the *sand* cays; that is, lithified sand as distinct from the partly or wholly cemented shingle found at the outer edge of the reefs. I made a distinction between coral conglomerate and beach rock, meaning by the latter sand rock. Then, as Sir Matthew Nathan said, negro-heads are frequently found on the north-west side as well as on the outer, or south-east (weather), sides of reefs. Of the latter we saw very many examples. The negro-head is one of the features which is often very noticeable at a distance, as it is miraged so as to appear several feet high. When you get to it it is usually quite small.

At this hour I do not want to enter into an argument with Professor Gardiner. I quite appreciate what he says, and I fully realize the importance of eustatic movements of sea-level. But it often happens that such movements are as difficult to support as to defend in certain areas (such as, I think, there are in the Barrier), which have moved independently of a region as a whole. Although I am by no means certain, I think there are parts of the northern area which are definitely faulted down. I think, too, there is much to be said for the future of geodetic work in this particular region. But, as I probably did not point out quite effectively enough, the absence of cliffing does show that a rise of sea-level, or a sinking of the reef foundation, took place concurrently with the growth of the reefs. The existing cliffs, which are small, are formed by the lagoon waves.

The PRESIDENT: We all hope that the alliance between geography and biology will not be interfered with by eustatic movements of sea-level. We are very much indebted to Mr. Steers for his lecture. He has given us an interesting account of the Great Barrier Reef, the firstfruits of the expedition in which we as a Society were interested and helped to pay some money towards. We shall hope to hear more from him and his companion Mr. Spender. In your name I thank him heartily for his lecture.

THE ORIGIN OF THE FAIYUM DEPRESSION: A CRITICAL COMMENTARY ON A NEW VIEW OF ITS ORIGIN

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THE origin of the series of basins occurring about an east–west line across the Libyan Desert has often been under discussion, and in the main has been attributed to wind erosion acting on soft rocks intercalated in harder strata.

Quite recently a new and interesting theory has been put forward by Messrs. K. S. Sandford and W. J. Arkell to account for the most easterly of these depressions—the Faiyum Oasis. This depression differs from all the others in the series in being connected with the Nile Valley by the Hauwaret Channel, through which flows the Bahr Yusef, a stream taking off from the Nile at Asyut, some 200 miles to the south. It appears to be a natural channel, possibly once the course of the main stream, left, by a subsequent change of direction, to meander close under the cliffs bounding the western side of the Nile Valley. It is now regulated for irrigation purposes, but if uncontrolled would flood the Faiyum, since it enters it at a level of 28 metres, while the bottom of the basin is at −50 metres (see map, Fig. 1, following p. 416).

The new theory claims normal river action as the main agent in the excavation of the Faiyum from Pliocene or earlier times to the post-Palaeolithic period. The depression was then thought to have been cut to its present depth of 50 metres below sea-level by a tributary to the Nile, at that time flowing below its present level, and joined to the Faiyum by a deep gorge through the Hauwaret Channel, since silted up by the aggrading stream. On this view, therefore, the Faiyum as we know it now is of very recent origin.*

It is this statement, for which, unfortunately, no evidence is given, that I feel can be left no longer unchallenged, for it has a direct bearing on the character of the Palaeolithic and Neolithic lakes that I have been studying for two seasons, mainly in the northern desert area.

The accepted view of the origin of the Faiyum Depression is that given by H. J. L. Beadnell in his Survey Memoir on the district, published in 1905.† The main points in the two theories are summarized in the table on p. 372, and in the diagrams in Fig. 3, following p. 416.

The essential differences in the above views are firstly, that Beadnell considers that the erosion of the depression had already begun in the Pliocene, and had been completed by the Pleistocene, while Messrs. Sandford and Arkell think that the final stages were not accomplished till post-Pleistocene times. Secondly, on Beadnell's theory desert conditions had already set in before the formation of the Pleistocene lake, while Messrs. Sandford and Arkell would put this occurrence well on in the post-Pleistocene. Finally, with this last point can be correlated the divergence in opinion as to the agents mainly concerned with the erosion of the depression. Beadnell would ascribe to wind action

*The source of these and all subsequent statements by the same authors are to be found in *Nature*, April 1928, p. 670 and *Man*, April 1929, pp. 66–69.

†'Topography and Geology of the Fayum Province' (Cairo, 1905), pp. 71–81 and 25–26.

TABLE OF EVENTS IN THE FAIYUM ACCORDING TO

	H. J. L. Beadnell.	K. S. Sandford and W. J. Arkell.
Middle Pliocene ..	Marine beds up to 60–70 m. (197–230 feet). Faiyum probably already considerably eroded.	Marine beds up to 100 m. (328 feet).* Sea-level 170–175 m. (558–574 feet). Gulf over south-west of Faiyum.
Upper Pliocene	Gravel terraces; top 170–180 m. (558–590 feet), =shore-line of isolated lake or sea. Faiyum =approximately its present form and dimensions except for depth.	Gravel=remnants of river valleys draining into Nile across Faiyum, which did not then exist as a depression, but formed part of the Libyan Plateau. Gravel correlated with estuarine beds of Nile Valley, unconformable on marine series.
Plio-Pleistocene	Drying up of inland water with deposition of gypsum on gravel. Erosion of depression to present shape and depth. Desert conditions established.	Erosion of Faiyum by normal river action. Formation of low-level plain and escape of drainage into Nile by the cutting of the Hauwaret Channel.
Pleistocene .. .. Middle to Late Palaeolithic	Breaking in of Nile by the Hauwaret Channel and formation of lake at 22 m. (74 feet). Cutting of deep Nile Channel and possible isolation of Faiyum lake for a short period.	Formation of lake at 34–35 m. (112–115 feet) by reversal of drainage through the Hauwaret Channel in Middle Palaeolithic times. Fall of lake, with long pause at 28 m. (92 feet)—Lower Sebilian (Late Palaeolithic), and another pause at 22 m. (74 feet)—Upper Sebilian. Heavy rainfall throughout Palaeolithic times.
Transition to Neolithic	Lake maintained by rising Nile.	Erosion of Faiyum to below sea-level by the action of a normal tributary river to the Nile, flowing through Hauwaret Channel, as Nile cut deep gorge to unknown depth below present sea-level. Establishment of desert conditions as Nile began to aggrade its bed.

*All heights throughout the paper have been reduced to metres above present sea-level, in order to conform to the maps of the Egyptian Survey here utilized. The figures in brackets represent the corresponding height in feet. The average height of the Nile in the Faiyum region has been taken as 28 m. (92 feet) above sea-level.

the dominant position, while Messrs. Sandford and Arkell regard normal river erosion as the main operating agent.

The available evidence for and against these two views will now be discussed for the different periods. The latest Tertiary rocks in the bordering scarps of the Faiyum are of Oligocene age, and it is probable that, during the Miocene and early Pliocene, erosion would have been acting on the newly uplifted plateau. Now the beds dip gently northward, and the sea also lay in that direction, therefore the consequent drainage must have been to the north also.

Miocene.—During the Miocene, as Messrs. Sandford and Arkell have shown, and as is, indeed, obvious from Blanckenhorn's published sections*, the Nile cut a deep valley along its present course. At this period, therefore, subsequent drainage would have developed from the edge of the Libyan Plateau to the Nile; to this may possibly be ascribed the easterly slope of the series of plateaux in the northern Faiyum (see map).

Pliocene.—There is general agreement about the Middle Pliocene sea, but the Upper Pliocene gravels require further consideration. The isolated gravel outcrops fall into two series according to Beadnell's description of them: (1) A northern group extending from the west end of the present lake to the north-eastern border of the depression. (2) An eastern and southern series, for the most part capping the divide between the Nile Valley and the Faiyum. The northern group have an average elevation of 170 m. (558 feet) and consist of coarse gravel with blocks of limestone, fossil wood and basalt, the two last being derived from the Oligocene beds to the north of them. They occur below the present rim of the depression, and were considered by Beadnell to have once formed a continuous terrace (see map).

The eastern group, however, is at a much lower level, the upper limit ranging from 70 to 150 m. (230–492 feet). They differ from the northern, also, in occurring on top of, not below, the Nile Valley divide. This series generally begins with a coarse, almost breccia-like deposit, containing large blocks of local Eocene limestone, sometimes exceeding 10 feet in length. With the rolled flint and quartz pebbles of the gravel are rounded blocks of silicified wood. The sandier beds are in places seen to dip 10° east. There is, according to Beadnell's figures, a remarkable irregularity in the Eocene floor on which the deposits are laid. He gives the height of the base of the gravel in some places as 65 m. (213 feet) above sea-level, while in a section close by, they are at only 27 m. (88 feet).

Taking all the above facts into consideration, it would seem that they fit in better with Messrs. Sandford's and Arkell's " river " theory than with Beadnell's lake terrace idea, providing all the gravels are of the same age. But—and this is important from the point of view of the subsequent history of the Faiyum—the Oligocene beds had already been completely removed from the greater part of the present Faiyum area, and in the north, according to both views, had reached practically their present position. Also erosion in the exposed Eocene had already been carried to a relatively great depth in Upper Pliocene times, with regard to the top of the plateau, at present at 340 m. (1115 feet). The valleys near their mouths on the eastern side of the Faiyum were then at least 275 or 313 m. (902–1027 feet) below their source.

*M. Blanckenhorn, "Ägypten," Hand. Reg. Geol., Heft 23 (1921), pp. 138 and 158.

*All heights through[illegible] in brackets represent the corresponding height in feet. The average height of Survey here utilized. The figures in brackets represent the corresponding height in feet. The average has been taken as 28 m. (92 feet) above sea-level.

The gravel is regarded by all parties as of Upper Pliocene age; when, then, did this great amount of vertical cutting take place? The absence of marine fossils from the gravels would seem to indicate that the valleys were not in existence before Middle Pliocene times; neither is it probable that they were cut to a rising water-level. The only available period is, therefore, the interval represented by the unconformity between the estuarine and marine beds. If this be correct, the Pliocene sea must have fallen, according to Beadnell's figures, to at least 27 m. (88 feet). The significance of the unconformity has not been dealt with by Messrs. Sandford and Arkell, but if it can be interpreted as above, is it not possible that in this interval of vigorous erosion the formation of the depression had already begun? The high level of the northern gravels does not necessarily mean a corresponding height for the rest of the area. The northerly dip, combined with the varying hardness of the beds, must have given rise to a series of dip and scarp slopes. At the foot of the scarps the drainage of the dip slope below would have collected then as it does now, forming a system more or less isolated from those above and below it.

Let us, then, provisionally accept the possibility of the erosion of the Faiyum in Pliocene times by river action, with the proviso that the extent and depth of that erosion may have been much greater than seems to be indicated in Messrs. Sandford's and Arkell's account.

Plio-Pleistocene.—It is when the attempt is made to carry this process uninterruptedly to Middle Pleistocene times that serious difficulties appear. During the Plio-Pleistocene, according to Messrs. Sandford and Arkell, the Nile recut its valley in a series of four terraces ranging in the Faiyum region from 171 to 74 m. (561–243 feet) above sea-level*, meandering at times over the " region now the Faiyum." This would seem to imply that during this period no depression existed at all in the Faiyum area.

There is some ambiguity as to the course of events in the Faiyum at this time, for the level of the plain said to exist then is not given, nor whether the connecting channel was cut immediately, or only after sufficient water had accumulated to top the divide between the Faiyum and the Nile. Since, however, it is explicitly stated that a lake first appeared in Middle Palaeolithic times, we must choose the former alternative. This being so, the level of erosion in the Faiyum must have been controlled by the level of the Nile outside. Presumably the mean height of the Faiyum plain could not have been below the terrace levels, otherwise the drainage would have been reversed, which, according to Messrs. Sandford and Arkell, did not take place till Middle Palaeolithic times. The most conspicuous plain at present in the Faiyum is found in the north-east, extending from below the boundary scarp for 7 miles to the south. It may be called the Gindi Plain, from the conspicuous isolated hill of that name (see map). It ranges in height from 140 to 31 m. (459–102 feet), the southern edge forming a gravel-covered scarp abundantly strewn with Mousterian implements. The contours around the margins of the plain must be examined for evidence of the headwaters of the streams that formed it, for since emphasis is laid on the normality of the river action, some indication should exist of the mature and young stages of which

*These figures represent the extreme limits of the terraces. The figures in the diagram, Fig. 3, refer to the upper limit in each case.

the plain represents the old age. To begin with, the watershed lies very close to the northern rim of the depression, a gentle northward slope beginning only about 4 miles from it. There is no reason why the watershed of early Pleistocene times should have been farther away, therefore there was no extensive area to the north on which the drainage of the Faiyum could draw. Further, there is no indication in the contours of any conspicuous valley system, such as should be preserved in the harder Oligocene rocks, which, according to Messrs. Sandford's and Arkell's own showing, have only retreated a very short distance since they formed the northern wall of the Upper Pliocene gravel. Why, then, are there not more signs of the very extensive drainage systems, formed under conditions of heavy rainfall? If stream erosion can be postulated, let it not be called "normal" in the accepted sense of the term.

It must be admitted at once that the Tertiary of the Faiyum shows abundant evidence of erosion, especially in the north-eastern region. The scarps are cut back in broad "Vs," but these valleys extend, as a rule, only a relatively short distance into the dip slope above, and generally end abruptly in a vertical cliff. They suggest the action of intermittent streams and torrents, heavier, indeed, than those of the present day, but not such as would give rise to a normal stream, taking that to mean one with a continuous, not a periodic, flow. Wind and weather would in that case be as much responsible for the land forms as water action.

Some such combination of agencies may be assumed to have been in operation during the Plio-Pleistocene on Beadnell's view of this period (see table). The essential difference between the two conceptions is that Beadnell believes in the isolation and erosion of the Faiyum to its present shape and depth before the formation of the Pleistocene lake, which was formed by the breaking in of the Nile along the Hauwaret Channel, while according to Messrs. Sandford and Arkell there was an extensive plain draining by normal river action *into* the Nile, that is, the Hauwaret Channel was cut in the reverse direction and at an earlier period than on the older view. The actual means by which the dividing ridge was breached is not explicitly stated in either case. Beadnell, however, suggests that the partially consolidated gravels of the narrow divide were easily worn away by a Nile flowing, in those days, both more rapidly and at a higher level. It is possible to imagine that lateral erosion of the main stream gradually undermined such material, breaking a way through the ridge.

Pleistocene.—The evidence for the flow of the Nile into the Faiyum in Middle Palaeolithic times is well established by the swinging in of the Nile 35 m. (115 feet) terrace, as Messrs. Sandford and Arkell have shown. But here another and serious difficulty presents itself on the evidence given. If the above is a correct interpretation of the theory, why did reversal occur, and what opportunity had there been for any basin to form at all in which the Nile waters could collect? This vital point has been left unexplained. It was not, apparently, because the Faiyum "tributary" lacked water; on the contrary, Messrs. Sandford and Arkell specifically state that the rainfall was heavy throughout Palaeolithic times. Again, the change does not seem to be due to the Nile, which continued to cut down its bed as it had done in the previous period.

The crucial question of the extent of erosion of the depression before the

formation of the Middle Palaeolithic lake can be tested by an examination of the floor on which the earliest deposits were laid down. This will now be undertaken, beginning on the northern side, where the lacustrine beds are best exposed. These deposits were examined, levelled, and mapped by me while working on lake problems in conjunction with Miss Caton-Thompson's archaeological investigations in the season 1925–26. An account of them has already been published in the *Geological Magazine*, September 1927, pp. 386–410. It will therefore only be necessary to pick out those points relevant to the present discussion.

Below the temple of Qasr es Sagha, which stands near the foot of the first steep scarp of the northern rim (see map), the earliest lake-beds consist of a series of white diatom clays, some 10 feet thick. They pass under the coarse detrital material of the later deposits, which here forms a steep cliff, close under the Tertiary scarp. A point that was made in my first paper, but now requires further emphasis, is that these white clays are not deep-water deposits laid down far from the shore-line: they must, from the topography, have been very close to the water's edge. Further, they are practically free from ordinary detrital material, and therefore the conclusion seems unavoidable that almost no drainage was entering the lake at that time. This must surely point to absence of rain, otherwise coarse material must have been washed in from the very steep slopes above. Moreover, this dryness was not a seasonal or periodic event, for no alternation of clays and sands is found, except in the higher beds, just before the series becomes completely detrital. I am quite unable to reconcile this undeniable fact with the continuous heavy rainfall postulated by Messrs. Sandford and Arkell for the whole of Palaeolithic times, but it does fit in very well with Beadnell's view that desert conditions were in existence before the formation of the Pleistocene lake.

On the south side coarser material is found overlying the Tertiary, and in this wind-cut and thermally fractured pebbles were found, confirming the evidence obtained in the north. Further, the complete absence of land shells from among the freshwater lake faunas, seems to me to point in the same direction. This holds true, not only for the lowest beds, but for the whole series, which have been searched very thoroughly.

Next the nature of the Tertiary floor on which these beds were laid must be examined. Section 1, p. 393, of my paper in the *Geological Magazine* brings out the fact that erosion had already cut this floor into a series of basins before the white clays were deposited, and that below Qasr es Sagha present sea-level had been reached prior to the Middle Palaeolithic period. Nor is this an isolated instance; practically every one of the depressions lying on the first plateau above the present lake tells the same story. Over and over again the earliest beds are found resting on an irregular surface, in some cases reaching to below present sea-level. When the lake-beds in the big depression between the eastern and western plateaux are considered, exactly the same thing is found. They sweep down into the low ground, which they once probably almost filled. Later erosion here, as elsewhere, has but re-exposed the original basins. Where the Tertiary scarp approaches close to the Birket Qarun along the north shore, the old lacustrine series behaves in a like manner.

Evidence of the great irregularity and low level of the pre-Middle Palaeolithic floor is also forthcoming on the south side. Beadnell noted the great changes of level in the Tertiary exposed in the two deep ravines of El Wadi and the Bats Drain, and that fact can be observed at almost any point along them. In some cases obvious channels had been eroded before the lake-beds were laid down, and these are in some cases cut nearly to sea-level or below it. Beneath the 'Idwa Bank, whose earliest beds belong to the 35 m. (115 feet) lake, the Tertiary floor is at about 14 m. (46 feet), and from there it falls ever lower as the Bats Drain is followed northward, and higher to the southward.

Had the drainage previous to the deposition of these beds been from north to south, as postulated by Messrs. Sandford and Arkell, the reverse slope should surely be detected. There is only one instance of this known to me, and that is supplied by the evidence of borings. In a bore put down at Madinet el Faiyum at 23·4 m. (77 feet) the alluvial beds were found to have a thickness of 18·5 m. (60 feet), thus bringing the Tertiary level in this region down to 4·9 m. (16 feet) above present sea-level. In a boring through the bank west of El 'Idwa, some 3 miles to the north of Madinet el Faiyum (for which I am indebted to Ahmed Ragheb Bey of the Egyptian Irrigation Department), the Tertiary level is 13·60 m. (44 feet). This agrees very closely with the figure given above for the level below the bank on the Bats Drain, about 2 miles east of El 'Idwa. Here then is a slope in the right direction for Messrs. Sandford's and Arkell's theory, but it is undeniably overlain by lake beds of Middle Palaeolithic age, when the Nile was running at 35 m. (115 feet), therefore it is much too low to grade into a river that must have been running even higher at the time of its formation. Further, borings on an island in the Bahr Yusef at Hauwaret (again kindly supplied by Ahmed Ragheb Bey) give the Tertiary level as about 21 m. (69 feet), therefore even this slope is not continuous southward, but the surface had just such irregularities as would be expected if it were the product of desert erosion. Moreover, if the higher parts of the Hauwaret Channel were cut by a river draining from the Faiyum to the Nile, the deposits formed at the levels corresponding to the Nile terraces should show a slope in the same direction. Perhaps they do, in which case evidence for the north to south cutting is conclusive, but up to the present the point has not been proved. The only indication given of the relation of the Nile to the Faiyum in early Pleistocene times, is the statement in *Nature* that implements have been found inside the eastern boundary of the depression in "a terrace or beach" at the same level as the Lower Palaeolithic terrace in the Nile valley, 46 m. (151 feet) above sea-level, or 18 m. (59 feet) above Nile. This does not throw any light on the problem of the direction of flow.

Middle Palaeolithic or Mousterian Lake.—The Mousterian lake at 35 m. (115 feet) with a storm beach up to 40 m. (131 feet) presents no problems; but difficulties again appear in the interpretation of the stages in the fall of this lake, and also in the dating of these later events.

Messrs. Sandford and Arkell, from evidence gained on the eastern side of the Faiyum, consider that there was a long pause at the 28 m. (92 feet) level, which they date as Late Palaeolithic (post-Mousterian and older Sebilian).

The lake then fell another 6 m., forming a beach at about 22 m. (74 feet). This is considered also to be Late Palaeolithic (probably Upper Sebilian) in age. It is this 22 m. stage, the highest known to Beadnell, that is discussed in my paper in the *Geological Magazine;* the earliest deposits there mentioned must now be considered to belong to the 35 m. lake.

The 22 m. level is hidden under alluvium in the Nile Valley and Hauwaret Channel; therefore, in the absence of numerous bore-holes, no direct evidence of the direction of flow at this or subsequent periods can be obtained. It is this subsequent history that is a matter of dispute.

Transitional Period to Neolithic.—On Messrs. Sandford's and Arkell's theory, as the lake fell in harmony with the Nile, drainage through the Hauwaret Channel was once more reversed, returning to its original Pliocene north–south direction. The cause of this reversal is not stated, nor yet the evidence for it. It is, however, clearly intimated that the Faiyum at the beginning of this period—transitional to the Neolithic—had not yet been eroded below sea-level, but that this took place *by the excavation of a normal tributary river valley* (the italics are mine), draining by the deep Hauwaret Channel into the Nile, which at this time cut its bed to some unknown depth.

The idea that the lake remained in communication with the falling Nile is not new, since it is implied by Beadnell in the Memoir already referred to (see table).

From evidence obtained on the north and south sides (the former already published) I am of the opinion that a break with the Nile such as Beadnell suggests did occur, though I am not prepared to state the exact height at which it took place. It was at this period, as I see it, that the re-excavation of the sites of the original Tertiary basins was begun, together with the extensive cutting back of the lacustrine deposits by subaerial agents, leaving isolated stacks among which the Neolithic people eventually lived by the waters of the later lake. But this conception of the erosion of the channel communicating with a lake basin already excavated to below sea-level is a very different one from that of Messrs. Sandford and Arkell, which would seem to involve the existence of an active and powerful river, flowing from end to end of the Faiyum. It has already been shown that the contours give no support to the hypothesis of an extensive river system in Plio-Pleistocene times; still less do they bear out the existence of this later "tributary."

The 30 m. and 20 m. contours are shown on the map, as being nearest the levels in question; it will be noticed that while the 30 m. contour indicates small valleys, presumably cut when the water-level stood at the 22 m. level (the 25 m. contour is also indented), the 20 m. in the same places runs practically straight. Where it does sweep into a valley, examination on the ground generally shows that the valley existed before the lake-beds were laid down in it, and that no conspicuous channel has been excavated after their formation. Surely if such extensive fluviatile erosion was in operation after the fall of the 22 m. lake, the 20 m. contour should show conspicuous V-ing. Its smoothness cannot be due to the deposits of the later lake, which did not reach to this level, and were not of any great thickness.

Since the only events that have occurred after the existence of the "tributary" are the rise and fall of this later Neolithic lake, the outlines of the river

system should be visible in the sea-level contour. I would submit that the shape of this line bears no resemblance at all to a normal tributary to the Nile, or, indeed, to a river of any kind (see map).

It might be argued that later deposits have masked its course, but in the south, except for the superficial recent irrigation material, the alluvial beds are admittedly mainly of Palaeolithic age; while in the north, the later beaches in some cases overlie the older series, which can be traced from higher levels passing beneath them, or they are banked up against the Tertiary. On Messrs. Sandford's and Arkell's theory these older beds should not be found at all at lower levels, since these levels had not yet been reached by erosion.

Another difficulty arises in this "river" theory. From what source did such a mighty stream flow that was capable of cutting a channel some 7 miles wide and 70 metres (230 feet) deep? The line of the Hauwaret Channel carried northward leads to the Gindi Plain, but this direction is precluded by the fact that the lowest part of the divide between the present lake basin and the first plateau is 3 m. (10 feet) above sea-level, therefore depths below this cannot be accounted for by a stream from this direction. Along the north-eastern margin the smoothness of the 20 m. contour militates equally against a possible source from here. There remains the western side of the depression. The 22 m. level was examined to the west of the present lake, where a conspicuous bank was found running first north-west to south-east, and then almost north and south, eventually merging in lake-beds at this general level, reaching right up to the northern boundary scarps. Narrow wadis break the line in places to a depth of about 4 m., but these soon lose themselves in the general level of the desert, and are obviously not the headwaters of the Faiyum "tributary." At the north end of these lake-beds the drop to a deep basin is very abrupt, and there is no sign of any large river.

In the deep bay east of Qasr es Sagha each successive Tertiary scarp shows a northerly dip leading into a depression almost completely isolated from the ones above and below it. Here again there is no trace of any big through channel.

The isolated gravel bank at Tamiya (see map), trending north-east to south-west, might possibly be considered a remnant of the course of this river. Shells in the lower part show it to be connected with some stage of the 22 m. lake, but its southerly extension through the Hauwaret Channel would seem to be debarred both by the westerly continuation of the El 'Idwa Bank, and by the 4 m. level of the Tertiary in the boring at Madinet el Faiyum. There is, however, a wide area covered with recent Nile mud, about which no direct information can be obtained, but it is to be expected that a stream capable of cutting such a big valley in the Faiyum itself, would also have widened its course through the Hauwaret Channel beyond the confines of the present Bahr Yusef, which occupies a relatively small area of the whole. So far as our information goes, this does not seem to be the case. Tertiary rocks can be seen along the banks of the channel in some parts, while the series of borings on the island at Hauwaret give a level of 21 m. for the Tertiary floor, with a gentle northerly slope (see Fig. 2). Again, at the intake end at El Lahun, the Tertiary close to the channel is at 14 m. (46 feet). These borings are not numerous enough to be conclusive, but as far as they go they do not favour

the existence of a deep and wide outlet channel for the Faiyum "tributary." If it did flow out, it would seem to have followed very closely the course of the Bahr Yusef, and of one or other of the deep and narrow drains.

The Bats channel is certainly later than the formation of the 'Idwa Bank, and must on this hypothesis have been cut from north to south. I know of no evidence to support this, nor any deposits of this stage showing a grade from north to south. In El Wadi the course of the sea-level contour would seem to indicate a banking of the waters on the southern side of the east–west Pleistocene gravel ridge, and the cutting of it eventually from south to north (see map).

Another question that is not touched on by Messrs. Sandford and Arkell is the source of supply of this "tributary." To accomplish such extensive erosion in the relatively short time between the end of the Palaeolithic and the beginning of the Neolithic, dated by Miss Caton-Thompson to about 6000 B.C. in these parts, it cannot have been a mere trickle but a stream of considerable volume. Now Messrs. Sandford and Arkell say nothing about heavy rainfall in post-Palaeolithic times, and since they are of the opinion that the 22 m. level is late in the Palaeolithic, presumably the source of supply was being gradually cut off till the final establishment of desert conditions, which according to them first took place when the Nile began to aggrade its bed. This unquestionably happened long before the advent of the Neolithic people, therefore the time available for the great amount of erosion is still further reduced, and the rainfall requires to be correspondingly heavier. This makes it all the harder to grasp the conception of a large tributary river flowing through the Faiyum. How was the necessary volume maintained?

Origin of the Wadi Rayan.—The origin of the low levels in the Faiyum cannot be considered without reference to the neighbouring Rayan depression. This is a closed irregular-shaped basin lying to the south-west of the Faiyum (see map). It reaches a depth of 42 m. (138 feet) below sea-level, and has no present connection with the Nile Valley, the lowest point on the divide between them being 50 m. (164 feet), while on the Faiyum side two narrow passes at 25 m. (82 feet) and 26 m. (85 feet) are the lowest points, the rest of the ridge varying from 34 m. (112 feet) to 40 m. (131 feet) on the east to 60 m. (197 feet) and over in the north and west.

Messrs. Sandford and Arkell state that they have found shells at a sufficiently low level on the divide to lead them to suppose that the Rayan was flooded by the Mousterian lake. If so, direct communication cannot have lasted for any great length of time, nor was the channel cut down *pari passu* with the fall of the Faiyum lake, as has been suggested took place in the case of the Hauwaret Channel.

Beadnell and earlier investigators found no trace of lake-beds in the Rayan, nor could any be found along the north-eastern side of the depression in the course of a traverse to the springs beyond Cape Rayan. Gravel, without shells, caps most of the isolated hills along the edge, but this must be of considerable age, since it is at 74 m. (243 feet) and over. The upper slopes are of Eocene limestone, while the lowest parts are largely sand covered, but no sign of lake-beds could be found where no sand lay at any level. If, then, the Rayan was flooded in Mousterian times it was evidently of short duration,

and gave rise to no such great series of lacustrine deposits as are found around the Faiyum. This is hard to understand on Messrs. Sandford's and Arkell's hypothesis of heavy rainfall throughout Palaeolithic times. If such did occur, why was the lake-level in the Rayan not kept up independently of that in the Faiyum? The singular absence of deposits would seem to indicate that this did not occur.

There is, however, one exception known to me to this general absence of alluvial material, and this consists of a considerable exposure of gravel in the area known as the Little Rayan, north of Cape Rayan (see map).

Our traverse crossed the gravels at their eastern limit, where they form a scarp running more or less north and south across the mouth of the Little Rayan. No shells or distinctive Nile Valley pebbles were found in the short time the gravel was searched, nor could it be followed to its source, which appeared to be towards the western limit of the depression. The eastern limit was, however, approximately fixed, and was found to be at least 10 m. (33 feet) below sea-level. This shows that the basin had already been eroded to a very low level before its deposition. The age of the gravel is uncertain, but in type it resembles that of the Gindi Plain. In any case it is unlikely that it is post-Palaeolithic, since at that time desert conditions were becoming established, and little or no water would be available for its deposition. If, then, it is Palaeolithic or earlier, the Rayan had already been deeply eroded at a time when, according to Messrs. Sandford and Arkell, the Faiyum was still at the 22 m. level or higher. It is difficult to understand why the agents which acted in the one case were not also operative in the other, since both depressions are essentially the same in character.

Conclusions.—From my own observations in the Faiyum I am, therefore, forced to disagree profoundly with the published statements of Messrs. Sandford and Arkell with regard to the "tributary" theory of the origin of the low levels in the depression, and indeed with such continuous and extensive river action as is postulated from Pliocene times onward. With this must be correlated a further disagreement on the question of climate; the facts seem to be all against heavy continuous rainfall, and in favour of dry periods separated by times of periodic rains heavier than those of the present day. This conclusion is also far more in agreement with the Pleistocene climatic changes that have been made out by Mr. E. J. Wayland in Uganda,* and Messrs. L. S. B. Leakey and J. D. Solomon in East Africa, who have recently published an outline of their results for Kenya in *Nature*, 6 July 1929, p. 9. There is very fair correspondence between the rainy and dry periods in that part and in the Faiyum, on our interpretation of the climatic changes. Messrs. Leakey and Solomon have discovered two major pluvials, an early one with a rise and maximum before Lower Palaeolithic times, then an interpluvial, followed by the second major pluvial, itself divided into two by a short dry period. The whole of the second major pluvial is covered by Mousterian and various modifications of it, and may perhaps be correlated with the Faiyum 35 m. Mousterian lake, its 22 m. pause, and subsequen shrinkage. In East Africa there followed a period of great aridity, which I

Geographical Journal, 74, 1929, pp. 133–134; and *Man*, vol. 29, July 1929, pp. 118–121.

would suggest might correspond with the drying up of the 22 m. lake and the period of subsequent desert erosion. In Kenya a third, but shorter, pluvial period follows. This would seem to be of the same age as the rise and maximum of the Faiyum 18 m. lake, since the Bühl period of Europe has been suggested independently for both of them.* Finally, the post-pluvial wet period in East Africa would fit in very well with one of the pauses in the fall of the Neolithic lake, which must, almost certainly, have been due to greater rainfall (see Fig. 3, following p. 416).

Whether the apparent correspondence between the two areas is confirmed on further investigation or not, it seems clear that the rainfall of East Africa in Palaeolithic times was periodic, not continuous. If, as there is reason to suppose, these climatic changes were due primarily to far-reaching, not local, causes, then periodic rain in the Faiyum would be expected, and the burden of proof for continuous heavy rainfall postulated by Messrs. Sandford and Arkell must rest with the authors of the hypothesis.

My own work in the Faiyum was begun on the north side, where the existence of the later Neolithic lake was first established; its detection in the south and west was a difficult matter, and it might there have easily been overlooked on account of the great development of the earlier beaches and the disturbance due to cultivation. I would suggest that it is possible that, as Messrs. Sandford's and Arkell's work was mainly on the eastern side, which was also the windward shore of the ancient lakes, the great development of storm beaches may have obscured their view of the less conspicuous events, such as the dry periods, which are preserved on the more sheltered northern slopes.

Finally, there is yet another point on which our opinions diverge, and that is on the question of the age of the 22 m. lake. This is mainly an archaeological problem, and as such I am not qualified to deal with it. The grounds for our belief in the Mousterian-Middle Palaeolithic age for this and lower stages are put forward by Miss Caton-Thompson in a recent letter to *Man*.† Messrs. Sandford's and Arkell's idea of the very late Palaeolithic date for the 22 m. level was strengthened by the finding of ten beaches below that of the 35 m. lake. It is interesting to see that Messrs. Sandford and Arkell have become converts to M. G. Hug's theory of a "multitude of lakes." ‡ This would seem to bear out my point of the difficulty of gaining a true view of the situation from the windward shore alone. We are all in agreement that the 35 m. lake fell, therefore it is not surprising that in places subject to more extensive wave action ten or more beaches might be found, just as at the present day heavy seas on a shingle bank leave successive ridges in their retreat. But it does not seem to me a necessary conclusion that any of these terraces involves a long interval of time. The value of the periods can, I think, be only justly estimated on the lee shore, where the size of the beaches are more likely to bear a relation to the time taken in their formation, while the exposed side gives a very good measure of the force of the prevailing winds. Judging on these grounds, the 22 m. level is the most important stage in the fall of the 35 m. lake. The V-ing of the 25 m. contour, which can be seen on the

*G. Caton-Thompson and E. W. Gardner, *G. J.* 73, 1929, pp. 37–40.
†*Man*, vol. 29, July 1929, p. 132.
‡G. Hug, "Le Moeris," *Bull. Soc. Roy. d'Géog. d'Egypte*, May 1927, pp. 1–50.

1/100,000 map, again points to the 22 m. not the 28 m. level as representing the longest pause.

Apart from the fact that we found in the north Mousterian implements associated with beaches at a low level, from the geological point of view I would suggest that the interval between the end of the Palaeolithic (indicated by the 22 m. level according to Messrs. Sandford and Arkell) and the beginning of the Neolithic—dated by Miss Caton-Thompson to about 6000 B.C.—is extremely short for the work accomplished, which consisted in (1) the cutting of the Nile Valley from 22 m. to below sea-level, presumably to at least −50 m. (164 feet), since the Faiyum "tributary" must have graded into the Nile; (2) the filling of this great trench with alluvium, and the formation of the Neolithic lake in the Faiyum; (3) the isolation of this lake by the silting up of the Hauwaret Channel when the 18 m. (59 feet) level had been reached, and its fall to about 10 m. (33 feet) before the advent of the Neolithic people. All this would have to be accomplished in a time of increasing desiccation, which would not hasten either the degrading or aggrading processes.

For all the above reasons Miss Caton-Thompson and I would regard the later stages of the 22 m. lake as Middle Palaeolithic in age, and are led to take a fundamentally different view of the course of events in the later history of the Faiyum Oasis.

While recognizing the value of Messrs. Sandford's and Arkell's contribution to the subject, we could have wished that their statements on such questions of widespread interest as Palaeolithic climates, etc., had been supported by at least an outline of the evidence on which they were based, and we look forward with much interest to the publication of the facts on which such a fundamentally new view of the origin of the Faiyum has been framed.

THE GLACIERS OF THE UPPER SHYOK IN 1928

CAPTAIN MALCOLM C. SINCLAIR

IN the autumn of 1926 a very large flood suddenly swept down the Shyok Valley, carrying away the suspension bridge at Satti just above the Shyok–Nubra confluence, and doing great damage both at the actual confluence, where the waters backed up the Nubra for 8 or 10 miles, and also downstream. The bridge at Satti was a link of very great importance on the Central Asian Trade Route, which was established as the result of the Treaty of 1870 with the Maharajah of Kashmir. The Shyok at Satti is a deep and fairly swift river, and some idea of the magnitude of this flood can be obtained from the fact that even though the river-bed at this point is about 1000 yards in width the water rose to a point about 30 feet higher than the highest normal summer flood-level.

The cause of this flood was more or less definitely known to be the bursting of a glacial dam in the upper courses of the Shyok, but the extent of the lake so formed was unknown, and it was not even certain which glacier had caused the actual stoppage. During the late spring of 1927 reports from Saser

Brangsa, where the trade route again crosses the Shyok, showed that a fresh stoppage had occurred above the ford, and a sub-overseer of the Kashmir Engineering Department was deputed to visit the spot. His report showed that the stoppage was due to the advance of the Chong Kumdun glacier, the most northerly of four glaciers which lie to the north of Saser Brangsa. He stated—I write from memory—that the dam was 300 yards long, 400 yards wide, and about 450 feet high. The length of the resultant lake he put at about 4 miles, with an average width of 300 yards.

Formerly the trade route followed the Shyok valley north of Saser Brangsa as far as Yapchan, and then east-north-east across the Depsang plains to the Karakoram Pass. Owing to the frequent advance of those glaciers to the north of Saser Brangsa and consequent stoppages, this route fell into disuse, and caravans now travel via Murgo and Kizil Lunga. This route, though longer, is free of snow and offers no difficulties other than the utterly barren nature of the country. It will therefore easily be understood that reports as to the state of affairs on the Upper Shyok were rare and unreliable. As the Kashmir authorities were naturally opposed to the idea of rebuilding the bridge at Satti in case of a repetition of the events of 1926, I, as British Joint Commissioner, decided to visit the site of the lake and dam, and collect information.

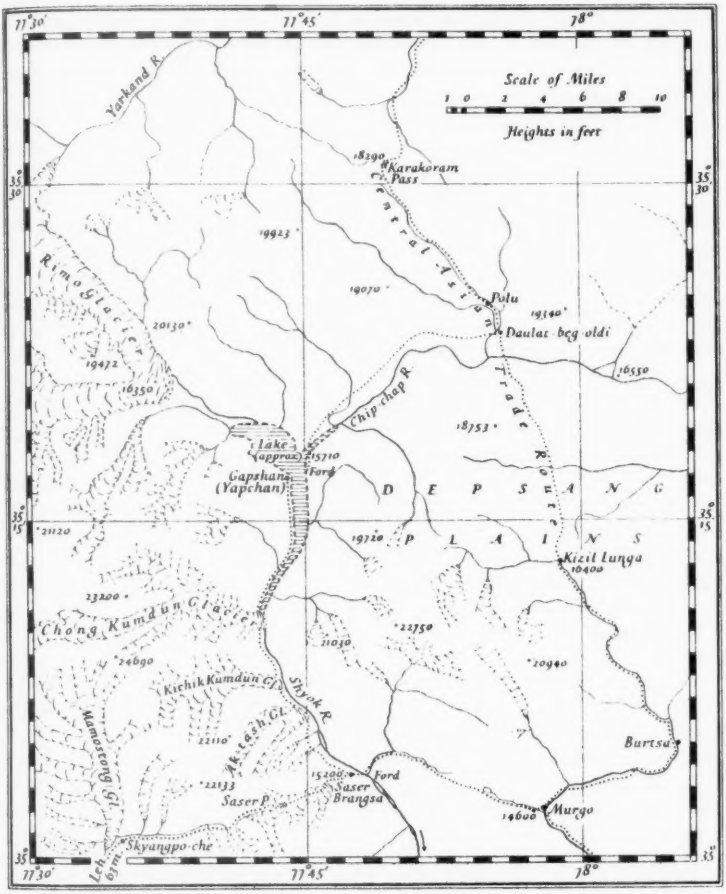
The expedition left Leh on 5 July 1928 and proceeded via the Khardung and Saser passes as far as Daulat-beg-oldi on the Depsang plains, and thence west to Yapchan. This detour on the Depsang plains was made in the hope of securing a Tibetan Antelope head, but in spite of an abundance of does and fawns not a single male was seen. A wild yak was seen on the foothills above Yapchan, which was reached on July 18. The Ladakhi pony-men stated that formerly yak abounded near the Rimo glacier, but none had been seen in that neighbourhood for years.

As soon as the expedition arrived near Yapchan it became obvious that the lake was very much larger than any of the reports had indicated. Observations showed that its level was rising rapidly, and the average daily rise during the three days' halt at the lake proved to be 27 inches. This rise appeared constant, and there was no noticeable variation between the rate of rise by day or night. During these three days a rough survey was carried out of the lake, which proved to be about 8 miles long, wide at the northern end and narrowing rapidly at the south, the average width being estimated at about 1000 yards. No boat was available, and though an attempt was made to obtain soundings from a skin raft, weather conditions made such navigation too dangerous, and it was only possible to obtain one set of soundings at a point about halfway up the lake, which gave a maximum depth of 80 feet in that section.

Traces of four different flood-levels were clearly marked along the eastern shore of the lake. The lowest, presumably that of the 1926 flood, was 4 feet above lake-level on the evening of July 19, the others being 18 feet 6 inches, 47 feet, and 63 feet above lake-level.

It was not found possible to reach the dam from the north, and accordingly the main camp was moved back to Saser Brangsa, and a very light camp sent up by coolies along the river-bed to a point on the west bank of the Shyok about half a mile below the dam, where a fair camping-ground exists. We ourselves

kept considerably higher, crossing both the Ak-tash and the Kichik Kumdun. It is known that both these glaciers have blocked the river-bed at intervals even in the last twenty years, but so far as is known the river has always eaten its way through, and no lake has been formed. Our observations showed that the



The glaciers of the Upper Shyok and the trade routes to Central Asia

Ak-tash was well across the river-bed and was still advancing; the Kichik Kumdun, on the other hand, was in retreat, and its snout shows signs of having suffered considerably during the 1926 flood. Personally I doubt whether the fourth and most southern glacier has been across the river for very many years; at any rate it is now about 3 miles away. Unfortunately the effect of the 1926 flood on the Chong Kumdun is not known. This flood took place unusually

late in the year (October 21), and no one ever saw the site until the glacier was again right across the river-bed in the spring of 1927.

Weather during the three days spent at the dam was extremely bad, and snow fell practically continuously. Partly for this reason, and partly through the lack of any climbing equipment, it was not found possible to cross the dam, and in consequence we were unable to obtain any soundings near it, and such observations as we were able to make were very general. The river valley north of the dam runs north-east, and the Chong Kumdun comes in from the north-west, the valley south of this point being about 600 yards wide, and to the north little more than half this width. The glacier at the point where it enters the river valley is about 400 yards wide, with very steep slopes on both sides; farther to the north-west there appeared to be a considerable basin, but the visibility was very poor. The actual dam was 330 yards long and 400 yards wide, with a minimum height of from 400 to 450 feet. The glacier abutted on a precipitous face of red sandstone, and at this point was at its lowest in a small dip about 20 yards wide and 40 feet deep. The level of the lake appeared to be about 70 feet below this point. Probably the reason for the existence of this dip was the radiation of heat from the rock face which catches the sun throughout the greater part of the day. There were no signs of percolation near the actual dam; a small stream flowed from the eastern corner, but this was almost certainly due to melting. About 600 or 800 yards downstream there were, however, some very strong springs which presumably owe their origin to the lake above.

It is not known whether the lake-level ever reached the top of the dam last year. The winter of 1928 set in unusually early in Ladakh, and it is possible that it did not. Another expedition consisting of an officer from the Punjab Irrigation Department and Mr. F. Ludlow are at the time of writing *en route* to the site of the lake, and as they have boats and proper climbing equipment, should have little difficulty in making a detailed survey of the lake and dam if it still exists.

The above account may be usefully compared with Mr. F. Ludlow's narrative in the first number of the *Himalayan Journal* of his visit to the Shyok dam only about a fortnight later. Mr. Ludlow had originally planned a visit to the Karakoram Pass, but when public interest in the condition of the dam became great, he decided to make a detour to the Upper Shyok valley. He was able to make no accurate survey, but his observations, mainly based on rough estimates, are interesting for the sake of comparison, as his visit followed so closely on that of Captain Sinclair.

Leaving Panamik in the Nubra Valley on July 24, Mr. Ludlow travelled by the trade route over the Depsang plains to Daulat-beg-oldi, which he reached on July 30. Descending the Chip-chap river next day, he encamped on the eastern shore of the Gapshan lake, a little north of the Chip-chap confluence. He estimates that the lake, which narrowed southwards to a breadth of only a few hundred yards, was then 1½ to 2 miles across at its widest part. The length he thought to be about 10 miles, and the average depth, by a rough calculation based on a 30-feet-per-mile fall in the river Shyok, about 150 feet. Like Captain Sinclair, he noticed terraces, indicating former lake-levels, on

the eastern shore, though he does not specify their number. Further, he states that one such terrace was then about 100 feet above the surface of the lake. The highest of the four terraces mentioned by Captain Sinclair was estimated to be 63 feet above the water on July 19.

Mr. Ludlow also comments on the rapid rise of the lake during his stay of two days, but the rate, according to his calculation for August 2, was then 18 inches in 24 hours, as compared with Captain Sinclair's estimate a fortnight earlier of 27 inches a day on a three-day average. It will be seen that snow fell practically continuously during Captain Sinclair's visit, and that there appeared to be no noticeable variation in the rate of the rise of the water between day and night. During the two days that Mr. Ludlow was there, on the other hand, the weather was particularly warm and sunny, so that the glaciers feeding the lake, he believes, were probably melting at their maximum rate. He suggests that on a cold cloudy day the rise observed on August 2 might have been halved or quartered.

Mr. Ludlow tried to make his way to the dam round the north and west shores of the lake, across the snout of the central and southern Rimo glaciers, which was about 7 miles from the Chip-chap confluence. The route to the snout, though crossed by a number of ravines, was not difficult, but seracs over 100 feet high at the snout made further progress impossible. The streams below the glacier also were too deep to ford. He therefore abandoned the attempt, and, after visiting the Karakoram Pass, returned via the trade route to Saser Brangsa, resolved to ascend to the dam from there.

On August 9 he started on foot up the valley with one Ladakhi pony-man and his Kashmiri tiffin coolie. He first encountered the Ak-tash glacier. It is particularly interesting to compare the accounts of this glacier given by the two observers. Mr. Ludlow states that its ice-pinnacles were for the most part 200 yards from the Shyok bed, and that only in one place did they actually reach the right bank. Further, he states that the glacier was in retreat. The Kichik Kumdun, which he reached next, appeared from a distance to descend and stretch right across the Shyok to cliffs on the left bank. When, however, the glacier was crossed, the tongue was found to terminate some 80 yards from the left bank of the Shyok.

Following the river, the party reached the north lateral moraine of the Kichik Kumdun, and from there saw the great dam about 2 miles ahead. They continued to within about half a mile of it, when, finding themselves in a cul-de-sac, they had to abandon the attempt to reach the dam, as it was then late in the afternoon and they had made no provision for a night in the open. Mr. Ludlow's study of the dam was therefore unfortunately limited to observation through glasses from the south, at a range of half a mile. So far as he could see from this distance, the Chong Kumdun glacier appeared to have turned down the Shyok river-bed for from 500 to 600 yards. The length of the dam he estimated at between 350 and 400 yards, and the height 200 feet at the snout, whence it rose steeply towards the lake behind. He remarked that the weakest part of the dam appeared to be that immediately adjoining the left bank, the point where Captain Sinclair had found it to be lowest. Like Captain Sinclair, also, Mr. Ludlow considers that there was little percolation from the lake through the glacier, the water issuing from the snout appearing to be mainly due to the melting of the glacier itself.

NOTE ON THE USE OF THE "WILD" UNIVERSAL THEODOLITE FOR ASTRONOMICAL OBSERVATIONS

LIEUT. DESMOND CRONE, R.E.

DURING the months of November and December 1928 various observations were carried out with the Wild theodolite to ascertain its utility for astronomical observations. These observations were in four groups: (i) the testing of the adjustments of the instrument, (ii) the practical use of the instrument in the field, (iii) the determination of the sensitivity of the vertical arc bubble by normal field means, and (iv) a rapid examination of the accuracy of reading of the micrometer.

(i) The instrument was found in perfect adjustment. The level of the trunnion axis was tested by determining the horizontal collimation error at angles of sight of 0°, 30° and 60° since a striding level cannot be used. The electrical equipment supplied with the instrument, viz. three frosted bulbs of 3·5 volts, flex and a small 4·5-volt battery, was not found suitable as the illumination was too bright and the battery soon exhausted. A battery box was made up to contain two "Ever-Ready" torch unit dry cells (total 3 volts) with a variable resistance of 6 ohms, which allowed the voltage with all three lamps alight to be varied from about 1·5 to 3 volts. The bubble was illuminated by a hand torch. A V backsight and bead foresight were fitted to the telescope of the instrument. The backsight was attached to the collar carrying the micrometer telescope, but was offset on a bracket about 1 inch long along the telescope to avoid danger to the observer's eye when using the diagonal eyepiece.

(ii) In the field about twelve hours of observing were attempted. The arrangements for illumination were satisfactory. The voltage range was sufficient to give a suitable field lighting for all magnitudes of stars observable. Two cells supplied light for an average of two hours.

The speed of observation was slightly greater than with a 6-inch micrometer instrument. A little difficulty was at first experienced in reading the reversed figures in the diagonal eyepiece and in appreciating the supplements (as opposed to the complements in an ordinary instrument) of the angles for setting when changing face. On the final evening of observing, when there was about 4° of frost, there was considerable condensation of moisture on all exposed glass surfaces and subsequent freezing. Very great difficulty was met with in removing this frost from the surfaces of the lenses by which the vertical arc beam emerges and enters in crossing the body of the instrument from pillar to pillar, as these lenses are recessed. Owing to this cause 70 per cent. of the time of observation was lost, and in observing for latitude by circummeridional stars none of the observations were balanced about transit time as in each case the glasses clouded up in about twelve minutes or at about the time of transit.

(iii) To observe the sensitivity of the bubble three independent series of observations were carried out.

(*a*) Vertical angles to a fixed terrestrial object at a sufficient elevation (40°) were observed continuously on one face with a dislevelment of the bubble and a displacement of the micrometer between each reading. The observations

were made between 12.45 and 13.20 p.m. on a day with a steady moderate breeze, but with light cloud-flecks at intervals which may have affected the illumination. The extreme range of the readings was 10·6, the mean error 3·0, and the probable error 2·2 seconds of arc for the series of sixteen readings.

(*b*) A scale was marked on gelatine and stuck on the underside of the bubble tube, and the bubble value determined in the usual way by displacing the bubble and reading the arc. The value of the smallest apparent displacement of the bubble was noted. This was done on each face, and for inch and millimetre scales.

The values determined were 0·1 inch = 48″ of arc
1·0 mm. = 16″ of arc
and the smallest apparent displacement (inch scale) 1·4″ of arc
(mm. scale) 1·6″ of arc

An error of the order of 1″ of arc seems to arise from the displacement of the line of sight by 10° from the level when viewing the bubble.

(*c*) A series of fourteen observations were made on one face to Polaris and the instants of observations taken. Each observation was reduced to the pole and the results compared. The extreme range was 11·0, the mean error 2·3, and the probable error 1·9″ of arc.

(iv) As an indication of the accuracy of reading the micrometer the telescope was clamped and thirty-two readings of the micrometer taken for this one position. The extreme range was 1·7, the mean error 0·33, and the probable error 0·28″ of the micrometer. It should be borne in mind when comparing these figures with those above that 1″ of the micrometer on the vertical circle represents 2″ of arc owing to the special way in which the vertical circle is divided. This method of division enables micrometer runs to be taken on the vertical circle, since for any one setting two coincidences of the circle divisions can be made within the run of the micrometer.

The length of one division on the circle was carefully measured at six points on the micrometer, each reading being repeated four times. The figures obtained indicate that there is a slight compression of the micrometer scale at one end as shown by the table :

Measure of one division of the Vertical Arc on different parts of the Micrometer

From 0′ to 5′	5′ 3″·3
1′ to 6′	2″·1
2′ to 7′	1″·5
3′ to 8′	1″·8
4′ to 9′	0″·0
5′ to 10′	0″·1

The lengths of divisions at intervals of 10° on the circle were read at a fixed point on the micrometer. The values of the seven readings, each taken three times, show an extreme range of 3″·7 and a mean value of 5′ 0″·8 read from the 4′ to the 9′ mark on the micrometer; the mean error of the division readings was 1·0″.

Finally, six divisions chosen at random were measured at random points on the micrometer three times each. The figures were corrected according to

their position on the micrometer by the graph, and the mean value of a division measured from the 4′ to 9′ mark on the micrometer appeared to be 5′ 0·6″.

Conclusions.—The most noticeable feature in these results is the large error in the micrometer run. This is so large comparatively that it can only be due to a faulty adjustment.

Such an error would have a serious effect on horizontal circle readings, though it need not affect the vertical readings if care be taken to make all readings on the latter half of the micrometer. It shows the importance of a thorough examination of the instrument before taking it into the field, and exhibits an advantage possessed by the instrument in having the vertical circle smaller than the horizontal circle, since this permits of micrometer runs being measured.

The remaining figures are remarkably consistent, and the figure for the probable error of a single reading of 1·9″ obtained from observations to Polaris which includes all errors likely to arise in the field, such as errors of intersection of the star, levelling the bubble, operating a stop-watch and reading the micrometer, gives a fair idea of the high accuracy which may be expected from the instrument. This accuracy is the more surprising in view of the relative insensitivity of the bubble. It would be interesting to obtain for comparison similar figures for the performance of this instrument fitted with a bubble two or even three times as sensitive. The one drawback located —that of condensation on inaccessible surfaces—could conceivably be obviated by fitting cover glasses or by making the protecting rims removable.

Note: At the recent exhibition of instruments at the Aeronautical Exhibition in London, the firm of Heinrich Wild showed an improved model of the Universal Theodolite, with contact rings for electric illumination that eliminate the need for flexible leads; with a simple form of sight on the telescope; and with a rack and pinion movement for the slipping piece which changes the micrometer over from vertical to horizontal. These improvements add much to its convenience for field astronomy.—ED. *G.J.*

EXPLORATIONS IN CENTRAL ASIA

INNERMOST ASIA : detailed report of explorations in Central Asia, Kan-su, and Eastern Iran. Carried out under the orders of H.M. Indian Government. By Sir AUREL STEIN, K.C.I.E. 4 vols. *Oxford: Clarendon Press* 1928. 13 × 10 *inches;* xl + xii + 1160 *pages;* 1 *volume of plates, and* 1 *case of maps.* £26 5*s*

IT is interesting to observe what first induced Sir Aurel Stein to set out on his travels in Central Asia, whereby he made those important geographical and archaeological discoveries which are now famous the world over. Apparently it was just a few fragments of ancient pottery and of birch-bark leaves found in the Taklamakan desert by Khotan "treasure-seekers," and taken in about 1895 to Ladakh by Yarkandi traders, who doubtless sold them in India as curios. But Stein and a friend of his, the late Dr. Rudolf Hoernle, an eminent Sanscrit scholar, soon recognized the significance of these objects: the birch-bark manuscripts, which were Buddhist texts, proved to be the oldest Indian writing then known; whilst the pieces of pottery which betrayed the influence of Graeco-Buddhist art, testified to the early spread of that art from Gandhara to Central Asia. However, interesting as these antiquarian remains were, they had but little value from an archaeological point of view, because there was no information as to their exact origin, or as to the sites where they were found. Stein resolved to make systematic researches at Khotan; and so he began his travels.

He has made three expeditions to Eastern Turkistan—in 1900–1, 1906–8, and 1913–16; and for them all he had the generous help of the Survey of India, which not only provided him with instruments and other equipment, but also deputed with him Indian surveyors of proved ability and energy. It is only right that men like Kam Singh, Lal Singh, and Afraz Gul, who had shared his dangers and hardships with extraordinary devotion, should now be associated with him in his successes.

Stein's first journey was within a relatively small area, being confined to the south-western corner of the Sinkiang Province; and in his 'Ancient Khotan,' we have a view of that region when it was still Buddhist and its culture rested on an Indian foundation. His second journey (recorded in 'Serindia') was more extensive, embracing the Lop Basin right up to the border of westernmost China, as well as vast stretches of the Kunlun and the Nan Shan ranges. But the most ambitious of them all was the third journey, of which the volumes under review are a report.

Here are a few rough indications of the routes followed.

Leaving Srinagar (Kashmir) at the end of July 1913, Stein made for Kashgar as his first objective; but as at the time of his start political conditions were not unfavourable for a passage through Darel and Tangir, valleys in the Hindu Kush never before visited by a European, he did some surveying there, tracking out at the same time the route by which Chinese pilgrims used to make their way down to the Indus. Then, travelling through Yasin, he crossed successively the Darkot glacier pass and the snowy ranges enclosing the headwaters of the Karambar and the Hunza rivers, and so reached the Taghdumbash Pamir. Thence he marched to Kashgar by an unfrequented route in the mountains of Sarikol, through the difficult gorges of the Qaratash river.

At Kashgar a new set of arrangements, suitable for desert travelling, were made. Camels were purchased. The native caravan-drivers whom Stein had employed on his previous journeys and with whom he had always kept in touch, all eagerly took service again with a master they well knew and highly respected. Preparations having been completed, Stein started for Khotan, but, as usual, by an unusual route. He first travelled to the oasis of Maralbashi by an ancient

road through the desert, and then he made his way to the dry bed, in the Taklamakan sands, of the Khotan River, following up the course of that river till Khotan itself was reached. En route, however, he made a short halt at Mazar-tagh Hill. There the remains of a Buddhist shrine were traced, and a quantity of ancient Tibetan manuscripts was found in an abandoned fort.

After a brief halt at Khotan, he set out on November 25 on his long journey eastwards. Some 700 miles still separated him from Lop Nor, and for the work planned for the desert region beyond no time was to be lost; for a waterless desert could only be explored when the winter cold made it possible for water to be carried in the convenient form of ice. None the less, whilst on the march towards Lop Nor, Stein managed to give some attention to ancient sites in the desert where he had excavated during his previous journey. At Niya, a further collection of Kharoshti documents on wood was made; and Miran yielded to him some more fresco paintings discovered in Buddhist shrines.

From Miran, Stein started on his explorations in the waterless desert of drift sand, east and north of the Lop Nor swamps. This led him to the ruins of Loulan, an ancient Chinese frontier post surrounded by a wall. There, from some grave-pits of the first centuries before and after Christ, he recovered a mass of remarkable textiles, including specimens of the earliest known figured Chinese silks, and some tapestries showing clear evidence of Hellenistic art influence. The human bodies found were in a wonderful state of preservation, these betraying, not a Mongolian, but a *Homo alpinus* racial type, with the face narrow across the cheeks, eyes straight, and the nose high and aquiline. There must have been, of course, in former times a route connecting Loulan with Tunhwang. Stein traced it—an enterprise attended by no small risks, seeing that on the ground to be crossed, which was no other than a great basin once filled by the Lop sea, neither water nor fuel was to be had, and it meant at least ten days' hard marching through the wilderness before the Tunhwang caravan track, farther south, could be reached. Nevertheless the venture was successful, and, what is wonderful to relate, the traveller was reassured in his orientation by a lucky find, on the dried-up sea-bed, of some first-century Chinese coins which, scattered here and there in a line, must have lain unheeded where apparently they had been accidentally dropped by passing caravans nineteen centuries ago.

Once having got to the vicinity of Tunhwang, Stein made a fresh visit to the "Cave of thousand Buddhas," which resulted in "a not inconsiderable addition to the collection of Chinese manuscripts which he had recovered in 1907 from the great cache of its walled-up chapel, in the shape of some 570 well-preserved rolls containing texts of Buddhist Canon." Moreover, he continued his explorations of the Han *Limes*. If to what he now discovered of this ancient frontier wall were added the portion traced in the course of his 1907 expedition, the whole would make a fortified line extending from the north-west of Tunhwang to Maomei in Kansu, that is, some 300 miles long, from east to west. As shown by Chinese documents on wood found in ruined watch towers, this *limes* must have been erected at about 200 B.C.—a date roughly corresponding to that of the reign of the Emperor Chin Chih Huangti, who is credited with having built the Great Wall of China. The Etsingol Valley, in South Mongolia, where abundant remains of manuscripts and block-prints in the Tangut and Tibetan languages were found, was about the easternmost point reached by Stein.

Thence he turned towards Kashgar again. But just as he had proceeded to Kansu by keeping to the south, *i.e.* in close contact with the Kunlun and the Nan Shan, so now, on his return journey, he kept to the north, by marching

across the barren ranges of the Pei Shan and along the Tien Shan, including portions of South Dzungaria.

The winter of 1914–15 was spent in survey operations in the waterless Kuruktagh ranges at the south of Turfan, also in excavations in the Turfan oasis itself, the proceeds including a large number of interesting mural paintings from Buddhist shrines. Finally, Stein returned to Kashgar in the summer of 1915; and after a busy stay there in arranging for the transport to Kashmir of his antiques (which filled 182 cases), he started on another journey, this time to Seistan, via the Pamirs, Gharan, Roshan, Shignan, Darvaz and Samarqand. Persian territory was reached partly by the Central Asian railway.

The operations in Seistan cannot be better summarized than in Stein's own words:

"My winter's work in that small but geographically very interesting *pendant* of the Tarim Basin was successfully begun with a survey of the large ruined site on the sacred hill of Koh-i-Khwaja. It was rewarded by the discovery of wall paintings and other remains going back to Sasanian times. While most of the numerous ruined structures examined in the Persian portion of the present Helmand delta were found to date from Mahammadan times, surveys in the desert to the south, once watered from a branch of the river, revealed remains dating from far more remote periods. There on wind-eroded ground I discovered sites of prehistoric settlements marked by stone implements as well as by abundant painted pottery closely linked in type with corresponding relics of Chalcolithic times that have come to light in localities so far apart as Transcaspia, Mesopotamia, Baluchistan and Western China. And across this area of prehistoric occupation, now all desert, I was able to trace a line of ruined watch-stations, which certainly dates from pre-Mahammadan times and curiously recalls the ancient Chinese *Limes* on the far-off Kan-su border. With a three-weeks camel ride by the caravan route connecting Sistan with the railhead at Nushki, my journey came to an end about the end of February 1916."

The above synopsis, incomplete as it is, will give one an idea of the immense extent of ground covered. Explorations in Seistan apart, Stein's travels had taken him from the Indian border near the Pamirs, through the whole length and breadth of Chinese Turkistan as comprised between the Kunlun and the Tien Shan, to the neighbouring province of Kansu: hardly a section had not been explored of that enormous basin of inland drainage, whose western rim coincides with the Imaos, cradle of the Oxus, and eastern, with the uplands of the Nan Shan, wherein are born the headwaters of the Hwang Ho.

But what of the tangible results of these travels?

Sir Aurel Stein has given us a series of new and accurate maps of an important portion of Central Asia; and it is not too much to say that, in view of their wealth of detail in the matter of physiographic surface features, such as belts of vegetation, living or dead; drift-sand formation, stationary or liable to movement; sea-encrusted grounds of different types, etc., they will be invaluable to the geographical student interested in Central Asia, not only as it now is, but also as it used to be in the early centuries of the Christian era. With the new materials at hand also, questions which have been exercising scientists, but which hitherto have been discussed with an insufficiency of data, such as the assumed change in the bed of Lop Nor, and the theory of secular change of climate in Central Asia, may now be approached with something like assurance.

But important as has been Stein's work from a geographical point of view, it has to be remembered that, for him, geography was only an adjunct to another science. His primary object was, of course, archaeology. And as an

archaeologist he is pre-eminent. No one, without his technical skill and topographical sense, his courage, and above all his diplomacy, could ever have explored and excavated in Chinese Turkistan with such marvellous results; and equally, no one without his scholarship and his mastery of exposition could have explained those results, not to the student alone, but to the average reader also, in a style clear and arresting, such as that of 'Innermost Asia.' Of the antiques, *i.e.* the archaeological "proceeds" of the 1913–16 journey, which have been admirably reproduced in vol. iii, space forbids details here. Suffice it to say that they include objects in metal, clay, glass, stone, lacquer, wood, pottery, etc.; stucco reliefs and terracottas; seals; coins (Chinese, Sino-Kharoshti, Indo-Scythian, Byzantine, Sasanian, etc.); pieces of woollen tapestries; figured silk fabrics; drawings on paper; rolls of Buddhist scriptures; block-prints; manuscripts on wood, paper, palm-leaf and birch-bark, in a number of languages, such as Chinese, Persian, Sanscrit, Kharoshti, Sogdian, Uigur, Mongol, Tibetan, Tangut. Most of these objects are of the third to the eighth century A.D.; but some are even earlier. They all bear testimony, however, to the fact that, beneath its present-day Islamic civilization, that part of Central Asia which is now known as Chinese Turkistan had in the past been subjected to a diversity of alien cultural influences—Indian, Graeco-Buddhist, Chinese, Tibetan, Sasanian, Manichaean, Nestorian. There has hardly been time yet for the examination and the decipherment of the thousands of ancient scripts brought home by Stein. When progress shall have been made in that work, who knows what new vistas may open out in the history of Central Asian civilization?

G. MACARTNEY.

HISTORY OF MARSEILLES

MASSALIA: Histoire de Marseille dans l'Antiquité, des origines à la fin de l'Empire Romain d'Occident (476 ap. J.-C.) By MICHEL CLERC. Tome I. Des origines jusqu'au III^me^ siècle av. J.-C. *Marseille: Librairie A. Tacussel* 1927. 11 × 8 *inches;* xii + 480 *pages; illustrations and maps.* 18*s* 6*d*

NATURE had provided at Marseilles the "factors" for the development of a great city; this book is the story of the Phocaean Greeks who first set these in operation and then exploited them to the full.

There was nothing unusual in any one of these factors, or even, perhaps, in their combination; to some extent they were repeated at Phocaea itself, and the ridge, the silted river-arm, the sheltering hills and islets, the neighbouring delta, are an association of the classic Mediterranean type. But at Marseilles the grouping was specially good: the position of the bay was excellent, on the flexure by which a concave arc of sandy or marshy shore curves into the convex line of a rocky and longitudinal coast; it gave a site as central in the most north-westerly of the Mediterranean ovals as a land site could be; and the topography, both of the oval and of the adjacent land-masses, was marked out on the broad and simple lines of the Western Mediterranean, favourable to the concentration of power, and contrasting so strongly with the fuss and fret of Eastern Mediterranean relief.

The Phocaean founders of the city which they called Massalia were not the first eastern people to visit this coast. Before their arrival the Ligurian peoples of the region had been in frequent, perhaps continuous, contact with the

Ionian Greek world for half a century. And, before that, the peoples of the hinterland had been in contact with the Eastern Mediterranean for an indefinite period, receiving by sea copper, and even bronze, implements some of which became patterns to the local smiths. It is not known who were the intermediaries in this obscure metal trade, which seems to be much earlier than the trade by the land-route across France, but two place-names suggest that the Phoenicians may have taken part in it: Phoinike, as one of the islets of the roadstead, may have been named from the purple-yielding gastropod which is, in fact, abundant in and around these islets; and none of the various conjectures for the origin of the name Massalia itself (Greek in form, but meaningless in Greek) is more plausible than that which derives it from the Semitic *mazzâl*, *massâl*, found in a bilingual Cypriote inscription as the equivalent of *τύχη*, luck, and surviving perhaps in the modern English slang-word " shemozzle." Did the Phocaean Greeks then take over a name with the site of their new foundation? This can only be a matter of conjecture, but, with their arrival in the early days of the sixth century B.C., conjecture gives place to formal history, which is henceforward continuous over two and a half millennia to the present time. No other city of the Western world can rival this record, with the exception of Rome; for Rome, however, the beginning of the independent city-state comes rather later.

The Massaliote Greeks had qualities to match the site. It is legitimate to see in its excellence *a priori* evidence of the forethought and skilful reconnaissance of the Phocaean settlers, and this scientific spirit, of prevision and of careful matching of aims with resources, set its mark on the commercial empire built up from this base, whose span—from Cabo de la Nao to Nice—no doubt measured nicely their naval strength. But there was more. If the city was a natural fortress, it was by the discipline of a Dorian austerity that the Massaliotes conserved here an Ionian civilization on the fringe of an alien world. If it was potentially a great trading centre, there was here the spirit of adventure to make it one, nurtured on the Homeric traditions of which Massalia was one of the six great shrines, and rising to its height in the immortal expedition of Pytheas. A balance of two opposing qualities is at all times to be discerned in the Massaliote character: adventure restrained by prudent realism; conservatism and elasticity, wedded in the unique political constitution on which their remarkable internal stability depended. Did any Greek city exhibit to such a degree this combination of culture and restraint? But it was the practical culture of the scientist and explorer, not the culture of the artist; at most the Massaliotes were the mere patrons and carriers of the art of the Eastern Greeks. Their initiative, too, was the initiative of the opportunist, not of those who shape destinies; thus their history is a reflex of events in a larger world, in which they played a role to which their representation at Delphi bears witness in the east, and their alliance *aequo jure percussum* with Rome, in the west, but in which they played no decisive part at critical moments. Two such moments bracket the apogee of their fortunes: the victories of Himera and Cumae made their empire possible; the setting of the stage for the struggle between Rome and Carthage marks the beginning of its decline.

On the whole the influence of a power which maintained itself so long against the Iberian and the Gaul, and against more remote intruders, seems disappointingly impermanent. Neither the Massaliote nor any other Greek influence can be traced on the Spanish Meseta; it has even been possible to assert, with exaggeration, that Southern Gaul owed nothing to the Greek but coinage and an alphabet. Has the Greek influence evaded analysis, or does its impermanence suggest the limitations of mere sea-power and of commercial opportunism, expressed on land in a policy of peaceful penetration? The Massaliote empire

was, in fact, set in the minor key so far as control on land was concerned; its forces were disposed, at points of secondary strategical importance to the landsman, so as to evade frictions, and to tap, but not to dominate, the valley-routes leading westwards by the Aude and Hérault, and northwards by the Rhône and Saône, and the great coastal route, as old as the Heracles legends, one section of which was to become the *Domitia Via* of the Roman.

In the end Massalia was absorbed by Rome, whose history was in some respects analogous, and which had been for so long bound to the Greek city by the tie of common enmities against Carthage and the Etruscan. But Rome was more firmly rooted in the soil and in its ethnic environment, the Roman was agriculturist and administrator as well as merchant, the Roman *imperium* came to be based on both land and sea power. To the people of the earlier period of antiquity Massalia and Rome must have seemed equals. On what differences could a prophet foretelling the future predominance of Rome have fixed? Perhaps mainly on a difference of character, one aspect of which is illustrated by the case of the treasury at Delphi: the Romans, a parvenu people, were introduced by the Massaliotes at Delphi and to the Massaliote treasury there; they ended by pushing the Massaliotes out of their own house. Moreover, though the ἀρετή and πόνος of the Roman, which to Strabo were more important than any natural advantages of the site, were not lacking to the Massaliotes, they brought sea-routes to Massalia, but made all land routes lead to Rome.

This is the web of History and Geography which M. Clerc reconstructs piece by piece before our eyes. In his exhaustive work no fragment of evidence is omitted; each is carefully weighed; no conclusions are forced. The reader sits as a member of a jury of laymen before whom a judge is summing up the conflicting evidence of experts in a long and intricate case—a most comfortable experience, remarkably unlike the sensations produced by the ordinary reconstructive work, which recalls at its worst the artificial reconstruction of detective fiction and at its best the party pleadings of a pushful barrister. The judge's *obiter dicta* on method are excellent, and apply *a fortiori* to other reconstructions, because there is here a starting-point in the known, with no highly contentious sites to be identified—Hemeroskopeion, perhaps, but the ink which has flowed round Hemeroskopeion has not been the red or purple ink which stains the sites of Tartessos and Atlantis.

The judge nods, of course, at times: a few minutes after he has discussed Agde, he tells us in a moment of lapse that, between the Rhône and the Pyrenees, the Iberians permitted the foundation of no Massaliote colony. There are places, too, in which the logic will not be accepted as sound by every one. For example, the termination *-briga* is claimed as Ligurian rather than Celtic on the grounds that it is commonest in Spain, where the Celtic element was weakest, and wholly lacking in Italy, where that element was most persistent. But *-briga castellum* (M. Clerc's own interpretation) may reasonably be expected to be commonest where a dominating people is most on the defensive, and, both on this interpretation and on the topographical, its frequency may be expected to vary with the topography.

Has M. Clerc not perhaps been biassed, too, by a preconceived theory regarding the Massaliote source of the *Ora Maritima*? The Massaliote practice was to reconnoitre carefully coasts on which they might later settle; here, embodied in the poem of Avienus, is a Massaliote periplus; there, on the Spanish coast, are the settlements of the second half of the fifth century; obviously the periplus is the report of a reconnaissance immediately preceding the settlements; it is to be dated, therefore, between 480 and 470 B.C. But there is a *petitio principii* in this statement which is not in M. Clerc's usual style; and, even if

we assume that the logic which associates the periplus with the settlements is sound, it remains to deal with the evidence from Emporion for the separation of the two in time by a greater interval than M. Clerc allows. The older site at Emporion has yielded potsherds dated *c.* 500 B.C.; are we not to suppose that they are remains from a Greek settlement? But if they are, then either the settlement is later than the periplus, which must accordingly be earlier than 500 B.C., or the text of Avienus passes over in silence a settlement which the original can hardly have ignored. M. Clerc's *obiter dicta* include many sound observations about the fallacy of the argument from archaeological lacunae; perhaps the argument from the silence of texts is equally unsound. Nevertheless it seems rash to fly in the face of such silence, especially as no violent improbabilities attach to the earlier date proposed by Professor Schulten. Moreover the common explanation for the silence of a text, that the writer had no opportunity to inform himself fully, is inadmissible here, where the only alternative is to suppose a lapse on the part of Avienus himself.

The weight of M. Clerc's summing up tells, however, because there is no elaborately constructed theory which a flaw in detail may bring to the ground; a supporting fact may be removed from the framework and made the centre of a group of facts set as accidents outside the general trend of the argument without affecting its stability. In a work which is far more than a mere history of the Massaliote Greeks, since it shows each fact in its intrinsic setting in the Greek world as well as in its extrinsic western setting, different readers will doubtless so separate different groups of facts; the value and charm of the work will remain.

In the volume under review the author brings the story down to the third century B.C., when the Massaliote power was at its height. As he points out in the introduction, the question of the detailed topography of the city itself does not enter into this period. That question, which is relevant to the protest of Professor Febvre against the *simpliste* tendencies of the historical geographer, belongs to the succeeding period and volume, which we await with interest. In that period, we are told in advance, degeneracy set in, and the Massaliote, who had been physical scientist and technician, became natural scientist, and his city a great medical school! R. A.

REVIEWS

EAST ANGLIA. By HUGH MEREDITH. *London: Robert Scott* [1929]. 8×5 *inches;* viii+344 *pages;* 20 *full-page illustrations and* 50 *pen-and-ink sketches from original photographs.* 7*s* 6*d*

The latest contribution to East Anglian "literature" is this volume in *The English Countryside Series*. It consists of the almost inevitably superficial observations of a motorist, recorded in a chatty style and filled out with guide-book information and notices of local worthies. It contains little that calls for special remark except some early nineteenth-century views and half-tone reproductions of one or two pictures by Constable, Crome, and Gainsborough. We start from Colchester and finish at Castle Hedingham (neither of which would be allowed by an East Saxon to be in East Anglia), and are taken at a leisurely pace up the well-known coastlands to Skegness and much more rapidly back by the less-known inland country. We are spared an account of Cambridge; but the cathedrals are described at length. Surely this has been done often and adequately enough before.

Of the pen-and-ink drawings we can only say that there can be little value in sketches taken from photographs, even if these are originals. J. H. R.

SUMMER DAYS AMONG THE WESTERN ISLES. By A. A. MACGREGOR. *Edinburgh and London: T. Nelson & Sons, T. C. & E. C. Jack* (1929). 8×6 *inches;* 342 pages; *illustrations and sketch-maps.* 7*s* 6*d*

To know the Western Isles is to love them. The author of this book assuredly does both. Moreover, he has the pen of a poet and his pleasant use of Gaelic turns to many of his phrases renders his style peculiarly suitable to the description of these romantic islands. His consistent and frequent use of cross-headings has its advantages sometimes. But where the old lady's description of a dictionary as "interesting but somewhat disjointed" might be applied, it is not so. When he is giving, for instance, a flowing description, their presence unnecessarily interrupts the continuity and is rather annoying. A good deal of the book would make dry reading for all but those who are keenly interested in the islands, but there are some good stories.

The volume contains a number of articles which first saw the light in periodicals. They have not always been edited so as to get rid of the faults to which such a practice is apt to lead. For instance, substantially the same incident is related on p. 52 as on p. 56 and the following pages. Mr. MacGregor's description of how genealogies are passed on orally from generation to generation is distinctly interesting. Apparently all clansmen worthy of the name consider it a duty to be able to give the details of not only their chieftain's lineage, but also their own for many generations, in some case as many as ten or twelve. This is an interesting example of what oral tradition in any part of the world may accomplish. Place-names in the islands have many charms, and Mr. MacGregor makes full use of them. His photographs are delightful. We have seen none better of the part of the world described. F. S. S.

FRENCH FRANCE. By OLIVER MADOX HUEFFER. *London: Ernest Benn, Ltd.* 1929. 9×6 *inches;* 286 *pages.* 10*s* 6*d*

This entertaining book recalls some of the writings of the late Constance Elizabeth Maud. A more accurate title would have been 'The French French'; for it is of the people, not of the country that the author writes. He takes as his types, not cosmopolitan Parisians, but first the citizens of a provincial town within an hour of the capital, and then the inhabitants of a large village in an

agricultural district. He guarantees the genuineness of all the characters and incidents described, though persons and places have been disguised under fictitious names. In all the twenty-seven chapters, or sketches, as they might be called, there is scarcely a dull page. The book is worth reading for its humour alone; but the reader can hardly fail to be imbued to some extent with the author's understanding of the mind and sympathy with the heart of the true Frenchman. Stress is laid on the enormous influence of the family and of the *pays*—that passionately adored little corner of France to which, rather than to a much more vaguely regarded *patrie*, every exile in the colonies ardently hopes to return to end his days. The consequence of this devotion is shown to be that the French have never been permanent colonizers after the English (or Spanish) pattern except in the single instance of Quebec, and that was due to the migration of whole families and even villages, with the resulting creation of a new *pays* and the ultimate transfer of allegiance to a new *patrie*. J. H. R.

A CANADIAN PANORAMA. By YVONNE FITZROY. *London: Methuen & Co.* 1929. 9×6 *inches;* x+204 *pages; illustrations and sketch-map.* 10*s* 6*d*

Travel books, if they are intended as informative surveys, are very apt to pall on the reader long before the journey is done. Miss Fitzroy has skilfully avoided the danger of cross-continent ennui. In the first place she accomplished her long tour from Cape Breton to Vancouver in an automobile; in the second, instead of confining her descriptions to the country, its flora and fauna, she has relied on her imagination to strike off impressionistic pictures of the people and their manners, and presumably on Baedeker researches to provide thumbnail sketches of historical centres of interest. She is pleasantly critical, and there are none of those prophetic platitudes which have to do with the "glorious future of a great Dominion." "Centuries hence Canada may become significant; at present her people are just as external to her as the European is to India. They have yet to create her, and they are very Presbyterian." As for the inhabitants of Sydney, Cape Breton Island, "they were not arrogant but just self-content in a perfectly kindly way."

Niagara and the Rockies gave of their age-old power, but the spell of the prairies enthralled the traveller most of all, and in strangely differing ways. There was mile upon mile of harvest, "broken, but so subtly that its domination is never for an instant in question, by the shadow of the ploughed lands, the silver of young barley, the Michaelmas daisies that carpet the rough ground and the woodland valley of the Assiniboine." On the other hand, miles distant, "daylight revealed the flat shadelessness of the Regina prairie, imposing in its way, but a white blaze dominated by a sun almost Indian in its intensity, utterly naked and swept by a high, hot wind. No trees shaded the little square farm-houses or gave relief to the grazing cattle. There was no relief on all the plain except the telegraph posts that marked our trail and curled like a banner of smoke to the horizon."

The chief attraction of the book is its personal appeal, a narrative of the adventures of a young woman gifted with certain shrewdness, imagination, and uncommon energy. The volume is well produced and beautifully illustrated. G. S. G.

BEYOND THE ROCKIES: Three Thousand Miles by Trail and Canoe through Little Known British Columbia. By LUKIN JOHNSTON. *London and Toronto: J. M. Dent & Sons* 1929. 8×6 *inches;* xii+212 *pages.* 10*s* 6*d*

Although the author modestly disclaims any intention of attributing to his work any of the characteristics of either literature or history, it does contain the raw material of both. On his long journey by trail, launch and canoe from Vancouver to the Peace River, Mr. Johnston talks with trappers, "sky-pilots," Indians,

cow-punchers, and those vanishing relics of pioneer days, the "old-timers," and he records it all as he goes along, almost in the manner of a diary.

The author has real powers of description, and purely as a record of travel the book sustains interest. But its main charm lies in its simplicity—as a tale of the lives of people who are building up British Columbia. By meeting and talking with such men as Charlie, postmaster, soldier and trapper of Gold Bar, one seems somehow to get a true glimpse into the lives of the more remote settlers.

There is one small and rather sketchy map. The photographs provide unusually beautiful illustrations. G. S. G.

THE ROMANCE AND RISE OF THE AMERICAN TROPICS. By SAMUEL CROWTHER. *New York: Doubleday, Doran & Co.* 1929. 9×6 *inches;* xx+390 *pages; illustrations.* $5.00

The American tropical countries dealt with in this very interesting book are the republics of Guatemala, Honduras, Salvador, Nicaragua, Costa Rica, Panama, and Colombia. The author holds that their European exploiters were guilty of a long-enduring error in thinking to take wealth out of tropical America without putting any in. He begins with a historical sketch, not impeccable in details, of the period of the Spanish Empire, and continues with an account of the appalling condition of the republics in the mid-nineteenth century. Independence had conferred no vestige of liberty, but only anarchy. Chronic warfare and revolution had killed whatever enterprise had once existed. Towns had decayed, and agriculture was practised only for bare subsistence. Outside adventurers, such as William Walker the filibuster, essayed to sup from this cauldron, but they usually found in the end that its presiding spirit had a longer spoon than theirs. After the filibusters came the concessionaires, who hoped to lift fortunes out of the apparently limitless natural wealth of the region. The appearance was deceptive, and the wealth was really a grinding poverty that could produce nothing.

Then, at the beginning of the present century, the United States brought new methods and men to the salvation of Central America, says Mr. Crowther, naming three events as inaugurating the present hopeful period—the formation of the United Fruit Company in 1900, the Washington Conference of 1907, and the opening of the Panama Canal in 1914. Of these he gives most prominence to the first. This great business enterprise has created a demand for the banana in the United States, has organized transport and distribution to the last detail of efficiency, and has revolutionized the tropics by remodelling their whole social life in the interests of production. It has resolutely avoided the fallacy of hoping to get something for nothing, and has applied capital, brains, and hard work to regions which it found derelict. The result has been political stability (except in Nicaragua), a new gospel of hope and ambition to the native, a rise in his standard of health and comfort, and a corresponding new market for American manufactures. The second half of the book gives a fascinating account of these developments. It is a chapter of economic imperialism little known in England and well worth comparing with parallel British work in tropical Africa and the East.

Of this comparison Mr. Crowther gives no hint. His outlook is American, as perfectly insulated as a high-power cable. He writes as if his countrymen alone had discovered the secret of tropical development. He refers often to General Gorgas but never once to Sir Ronald Ross. But we are too often guilty of the same insularity, and should be grateful to him for his corrective. His book is a fine essay in that combination of history, geography, and economic science which is so vital to citizens of the modern world. J. A. W.

ÜBER WESTMEDITERRANE GEBIRGSZUSAMMENHÄNGE. By HANS STILLE. Beitr. z. Geologie der westl. Mediterrangebiete, No. 1 (Abh. der Gesellschaft der Wissenschaften zu Göttingen, Math.-phys. Kl., N.F. 12, iii, 1927, pp. 62.)

In this monograph, prepared in connection with the Madrid Geological Congress of 1926, Professor Stille extends to Spanish tectonics inductive principles derived from the study of Central Europe. Mountains may be grouped in a single system if their folds belong to the same era of folding and have the same foreland. For discrimination between Foreland and Alpine zones no single defining character is available; neither structure, nor facies, nor date of folding is in itself sufficient, without taking into account relative frequency, scale, and distribution. As a corollary to this general statement, Foreland structures cannot be ascribed always to mere repercussions of Alpine movements, since folding of certain Mesozoic dates is a character both stronger and more frequent in Foreland than in Alpine areas.

Thus the structure of Saxony, the paradigm of a Foreland, is mainly independent of the Alpine movements. It has a tectonic individuality (interrupted, nevertheless, by Alpine reflexes) in which thrusting predominates, and in which the units have a characteristic north-westerly trend, which is neither Alpine nor posthumous-Variscan, even if it coincides frequently with the Variscan trend.

Broadly considered, the Pyrenees are seen to be true Alpides. *Nappe*-structure is well developed; although the east-Alpine and Pennine *nappes* are absent and the Helveticum has a Germanic facies, the Pyrenees may be taken as the last and most westerly term of a sequence which begins in the Eastern Alps, and from which the upper east-Alpine, lower east-Alpine and Pennine *nappes* disappear in turn. Moreover the greenstones in the Trias and the deep-seated intrusions accompanying the Mesozoic folding of the nucleus are Alpine characters. But, above all, the Pyrenees have fore-deeps both to north and to south towards which the folds "wander"; thus the inner zone, folded in mid-Cretaceous time, has been broadened by accretions on both the French side and the Spanish, due first to the main Pyrenean folding movements, and, later, to the movements at the close of the Oligocene, which affected principally the two fore-deeps themselves.

It follows that the Pyrenees are a true bilateral chain, in which the Alpides describe a narrow loop closed towards the west; the Southern Pyrenees are arranged in series, not in parallel, with the northern; after an interval of axial submergence, the Balearics and the Baetic Cordillera continue the series. To Fallot, Argand, and Staub Corso-Sardinia appeared to be the Foreland of the Balearic movements, but Corso-Sardinia, which includes the Hyères–Maures massif, is a typical hinterland from which the direction of push is outwards on all sides, and the dominant tertiary folds of Minorca turn their back on it. Minorca, apparently an anomaly, is most easily explicable as the remnant of an inner zone of earlier folding, while South-East Majorca, and Ibiza-North-West Majorca represent outer zones folded at progressively later dates.

Kober was wrong in describing the Celtiberic chains of the north-eastern border of the Meseta as the link between the Pyrenees and the Balearics, because these chains have the characteristic Foreland structure of Saxony; Alpine phenomena may be more frequent than in Saxony, but they are restricted to small zones and depend on local conditions, the Palaeozoic being overthrust commonly on both sides towards enclosed trenches of Mesozoic. And here Professor Stille's argument, up to this point restrained, takes to itself wings, soaring briefly over the rest of the Peninsula and alighting finally with the hasty

and rather extraordinary suggestion that, in so far as Alpine Foreland, the whole may be described by extension as Celtiberia.

Professor Stille's schematic method, with its insistence on the assemblage of characters and on such quantitative treatment as may be practicable, seems to a layman suggestive and fruitful so far as tectonics can be taken as a natural science. But, since a mountain range is neither a biological organism like a plant nor a physical organism like an engine, the method appears to have limitations outside which the fallacy of the argument by metaphor may creep in.

So far as the Iberian Peninsula is concerned, the author avoids the difficulty arising at the western end of the Pyrenees, where it seems impossible to draw a southern boundary to the system north of the line Haro–Pancorbo–Oña, and hard to separate the Pyrenean system, if it extends so far to the south-west, from the Cantabrian Mountains. Perhaps we are to follow out the conception of limits, and to expect a certain degree of continuity between the Asturian massif (taking it as the limiting case of an Alpine enclosed massif) and the limiting case of Alpides with which it is in lateral contact. However this be, in the line of tertiary basins immediately to the south, extending continuously from Salamanca, by Burgos and the middle Ebro, to Catalonia, a basin of the Foreland will certainly be in unbroken lateral continuity with the southern part of an Alpine fore-deep; it is true that there is a marked change of facies in the basin from the Burgos neighbourhood eastwards.

More important is the difficulty of applying the definition of mountain systems given above to mountains of the Iberian section of the Alpine Foreland, which the case of the central sierras, commonly grouped as the Central Dividing System, will illustrate. It is, in the first place, doubtful to what date the trend of the Palaeozoic east of Somosierra and of all the pre-Palaeozoic formations of this system is to be ascribed. One may suppose that there has been either pre-Hercynian folding (in the French and Spanish sense) on a large scale (this the author, following H.-Pacheco, excludes), or vigorous folding accompanying the fractures of a late-Hercynian phase (H.-Pacheco's view), which raises certain difficulties, especially in the trend of the eastern Palaeozoic (the Caledonian folds of Dantín and Staub); or the trend in question may be pure Hercynian, the convexity towards the south-west, which is in any case characteristic of the Hercynian arc, being here accentuated (Macpherson's view). There are obvious difficulties in the way of accepting each of these views, and the existence of this doubt surely justifies in itself a protest against the description of the Meseta as an extended Celtiberia. But no one denies the existence of purely tertiary folds continuing the line of the system in Portugal, so that it would seem that the Central Dividing System exhibits that extension in line which the author calls *Fortbau, continued from era to era*, the only question being how many eras are involved. Nor does any one deny the importance of the tertiary rejuvenation of ancient lines in the system. Surely these facts suggest that it is not possible to group rationally the mountain chains of the Meseta except in terms of tertiary movements. And for these movements the idea of a Foreland is not fruitful, since the older formations are pushed or thrust either towards interior basins or outwards towards a bounding geosynclinal. (Professor Stille's own data suggest, in fact, some degree of fanning as a normal structure in Foreland massifs; this recalls Staub's description of the Asturian massif as a *Fächermassif*.)

Perhaps the author did not mean his definition to apply to foreland systems at all, or to discuss the *Zusammenhänge* of smaller units than the Meseta itself as *Gebirg*.

But what the student feels the need of is precisely a definition of this kind, or at least a discussion on this plane of a region where the relations between the

movements of different eras are more obscure, and the tertiary lines, whether described in terms of *plis de fond* and *plis de couverture* (as Royo Gómez, following Argand, seems to do) or in terms of vertical movements with subordinate folding (as H.-Pacheco prefers), are more important, than elsewhere in the European Foreland of the Alpides. The important fact may be, however, the relative importance of the vertical component of the tertiary movements, not the relation between tertiary and earlier lines at all; in some places it is the vertical movement which impresses us, in others—on the plateau of Soria, for example—the tangential.

In any case the student is bewildered at present, not by the absence, but by the multiplicity, of suggestions of major tectonic lines for the Peninsula; until these are discussed as suggested it seems futile to argue whether the Sierra de la Demanda, for instance, belongs to the Celtiberic system or to the Cantabrian. Perhaps the discussion would be premature; then the *Zusammenhänge* are in the meantime arbitrary. R. A.

ERGEBNISSE DER FORSCHUNGSREISEN DURCH INNERASIEN. By G. PRINZ, Erster Teil der gesammelten Sonderdrucke. Beiträge zur Glaziologie Zentralasiens by G. Prinz, pp. 131–335, 5 pl.; Beiträge zur Petrographie Zentralasiens by S. V. Szentpétery, pp. 265–385, 3 pl.; Paläontologische Studien aus Zentralasien by M. E. Vadász, pp. 57–115, 4 pl.; and Második belsöázsiai utazásom néprajzi eredményei. (Ethnographie) by G. Prinz, pp. 1–63, 2 pl. *Pécs.* 1928

This work consists of a re-issue of memoirs on the expeditions in 1906 and 1909 by the Hungarian geographer Dr. Gyula Prinz in the Tien Shan, Eastern Pamir, and the western part of the Kunlun Mountains. The first memoir is on the glacial geology of that part of Central Asia, and was first published in Hungarian in 1916 as vol. 24, part 2, of the *Journal* of the "kir. Foldtani Intézét Evkonyve." Its translation into German is therefore convenient. There has been much discussion as to the extent of the former glaciation of Central and Northern Asia, and Dr. Prinz has collected much precise information as to the region extending from the Dzungarian Basin, through the Tien Shan and Ferghana, to the north-eastern Pamir. He enumerates 140 glaciers which were in existence during the time of the local Burkhan Glaciation, and have now either disappeared or been much reduced in size. The second memoir, by Dr. S. von Szentpétery, gives a detailed account of the rocks collected during Dr. Prinz's journeys. It is a reprint from the *Mitt. Jahrb. d.k. Ungar. Geol. Reichs.*, vol 21, part 9, and was issued in 1915.

The third memoir by Dr. M. E. Vadasz on the fossils collected is a re-issue of his memoir published in 1911 in vol. 19 of the same journal. The fossils are from the Devonian, Carboniferous, "Permo-Carboniferous" and the Ferghana Stage, which according to Dr. Vadasz represents two or three distinct horizons ranging from the Cenomanian to the Eocene. The last memoir in the volume is in Hungarian, and is an account by Dr. Prinz of ethnologic observations made on his second expedition. J. W. G.

ASIE DES MOUSSONS. Par JULES SION (Géographie Universelle. Publiée sous la direction de P. Vidal de la Blache et L. Gallois. Tome IX.) Première Partie: Chine-Japon, 1928; 276 *pages;* Deuxième Partie: Inde-Indochine-Insulinde, 1929; 280 *pages. Paris: A. Colin.* 11 × 8 *inches; illustrations and maps. Francs* 70 *each volume; Francs* 130 *bound*

Monsoon Asia is too often popularly considered as if it were synonymous with India, China, and Japan. The intervening tracts of Siam and Indo-China are passed lightly over. It is refreshing to find in Professor Sion's volumes a differ-

ent, but at the same time a sound, well-balanced, geographical outlook. Burma is divorced from India, with which it is so artificially linked by political ties, and placed in its proper geographical position, together with Malaya, as an integral part of Indo-China. Monsoon Asia thus comprises four primary divisions of roughly equal importance—India, Indo-China, China, and Japan. To these is added a fifth—"Insulinde"—comprising the islands of South-Eastern Asia. Not only does Indo-China bulk largely in the descriptive matter—occupying 83 pages compared with 112 for India and Ceylon, 122 for China and 78 for Japan —but it is obviously natural for the writer in his introductory section to draw examples from French Indo-China rather than from the India more familiar to English readers.

Monsoon Asia, thus widely defined, includes regions as diverse in character as the deserts of Sind, the equatorial forests of Borneo and the frozen wastes of Sakhalin—a total area populated by half mankind. Apart from the broad facts associated with the monsoons, there is little homogeneity about the whole. For these reasons, despite the two volumes, some of the regional descriptions seem at first sight to be disappointingly slight. Thus Burma is dismissed in four pages, Siam in two and a half, and Malaya in one and a half. But Professor Sion has read widely and wisely, he has the power of emphasizing the matters of real importance in a few lines, so that even these vignettes are of definite value.

The system adopted of giving a selected bibliography to each section, but of omitting references in the text, makes it very difficult to extricate the author's own ideas from those of the authorities he has used. Also it is not easy for the reader to verify any particular statement, and the system is particularly unfortunate in the general introductory sections. There the "mechanism" of the monsoons is described rather than explained, whilst the following classification of monsoon climates is used: A. Equatorial and subequatorial climates (Malacca and Malabar types); B. Warm climates (Hong Kong, Calcutta, Delhi and Indus types); C. Temperate climates ("nuance temperée" and "nuance froide"); D. Cold climates (Manchuria and Sakhalin). This classification seems to leave much to be desired; thus the "Hong Kong type" includes the whole of China south of the Tsinling and east of the Red Basin and Yunnan; Southern Japan, Formosa, North-Eastern Philippines, Tonking and Annam (with its peculiar rainfall régime) and the slopes of the Himalayas from Simla to Assam. The claim which these diverse regions have for being considered together is that they have at least two dry months, though there are exceptions even to this. Similarly the Calcutta type includes the Madras coast, Orissa, the Ganges Delta, the whole of Burma outside Tenasserim, as well as Siam, except the south.

Whilst it is possible to disagree with the author in certain matters of this sort, it must be admitted that there are also numerous statements which must be seriously questioned or definitely regarded as inaccurate. Some betray perhaps a lack of personal experience. Thus bamboo rarely grows with eng in the typical dry Dipterocarp forests (p. 25); the view given of the Yenangyaung oilfield shows the field as it was over twenty years ago (Pl. 87); the famous view of Java's active volcano, Bromo, is not taken from Tosari but is that which bursts upon the traveller's view after two or three hours' good going from Tosari through the jungle (Pl. 89). Other statements need careful qualification before they are to be regarded as correct. Thus the Arakam Yoma ranges cannot be described as " nées au Tertiaire " (p. 295); hydro-electric works in India are scarcely restricted to the south (pp.356–7); the bulk of the cultivation in the Dry Belt of Burma is not irrigated, nor is its natural vegetation high grass (p. 469); the Madrassi immigrants into Burma certainly do not nearly all marry Burmese wives, nor are the offspring (actually the despised zerbaddis) "absorbés dans la

masse birmane" (p. 472). In other cases expressions of opinion are in question. Does the Hooghly still bring down enormous quantities of sediment (p. 304); do the languages of Chota Nagpur predominate in the plantations of Assam (p. 309) or the forests of sal in the Madhupur jungle fall to the axes of the Santals (p. 307)? Surely it is unfair to ascribe the low density of population in the Mahlwa plateau to bad administration in the Native States rather than to irregularity of rainfall (p. 330); to accuse the Government of India of neglecting the development of waterways without referring to the drain of water to the irrigation channels (p. 350); to say that the hostility of England to Kemalist Turkey has exasperated the Moslems of India (p. 383); or to say that rice milling and oil refining are the only industries of the province of Burma (p. 383). Amongst small careless slips may be noted the reference to deodar as *Pinus longifolia* (p. 288) and to the *bhils* of Bengal as tanks (pl. 54).

It is unfortunate that these defects are widely scattered through the book, which is otherwise well arranged and pleasantly written, and produced after the same high standard as its predecessors. L. D. S.

THE CAMBRIDGE HISTORY OF THE BRITISH EMPIRE. Vol. I. The Old Empire from the Beginnings to 1783. Editors J. HOLLAND ROSE, A. P. NEWTON and E. A. BENILANS. *Cambridge: University Press* 1929. 10×7 *inches;* xxii+932 *pages.* 35*s*

The title of this fine volume, on which the editors are to be warmly congratulated, indicates its scope. It deals at first hand with every phase of imperial development during the period, except the Indian and Canadian, which are reserved for distinct volumes in the series. Geographers will probably be most interested in the first five chapters and in chapter fifteen. (There are twenty-seven in all.) Chapter i is a general introduction by Sir Charles Lucas. In chapter ii Dr. Williamson discusses "England and the Opening of the Atlantic"; in chapt. iii Professor Newton deals with "The Beginnings of English Colonisation," and in chapt. v with "The Great Emigration, 1618–48," subjects which he has made peculiarly his own. Chapt. iv is a vigorous bit of writing on "Sea Power" by Professor Holland Rose. In all these the written accounts of discovery and colonization are supplemented from MS. sources, and the reader learns how much travel and trade there was which left no narrative memorial in Hakluyt or elsewhere and no institutional memorial in a trading company with its records. Chapt. xv, by Miss E. C. Martin, is of the same class and puts in their proper place in imperial history "The English Slave Trade and the African Settlements." To this might be added Miss Penson's chapter on "The West Indies and the Spanish-American Trade, 1713–48."

Two other chapters by Dr. Williamson, though less geographical, are not less important, vii and viii, "The Beginnings of an Imperial Policy," and "The Colonies after the Restoration." Professor Charles Andrews of Yale contributes two massive chapters on "The Acts of Trade" [Navigation Acts, etc.] and "The Government of the Empire, 1660–1763." The international and political setting, the rivalry with Holland and France, the wars and the reactions of Europe on the Empire, are handled in a series of chapters by Professor Rose, Dr. Temperley, and Mr. Reddaway. Eighteenth-century colonial history proper, including the constitutional struggle with the American Colonies, is entrusted to Mr. Cecil Headlam, and there are several specialist chapters, legal, constitutional, military, economic and social.

The volume preserves a remarkably high level not only of workmanship but, if the word may be permitted, of readableness. Composite histories are apt to be dull, but this one hardly ever begins to be dull, even when most technical. It

has an admirably arranged bibliography of MS. and printed sources. It has enough footnotes but not too many. But it has no maps. For this there must be reasons, which one can easily imagine. But the editors give none. So far as their text goes the question of maps or no maps might not have occurred to them. Only very good geographers carry all the West Indies or all the West Coast in their heads; and a sketch-map of the American Colonies at various dates would have been convenient. Many and expensive maps are not wanted; but something like the excellent skeleton cartography of the Cambridge Ancient History would have added to the value of a most valuable volume. J. H. CLAPHAM.

A CENTURY OF EXPLORATION AT NINEVEH. By R. CAMPBELL THOMPSON and R. W. HUTCHINSON. *London: Luzac & Co.* 1929. 9×6 *inches;* 146 *pages; illustrations and plans.* 7*s* 6*d*

The reasons for writing this little book are frankly stated by the authors in their preface to be the increasing interest in the recovery of the history of the ancient past, in which Nineveh was a city of great importance, and the desire to obtain funds for its further excavation. It is therefore of the nature of a popular appeal. Owing to its condensation, and to treatment from a strictly excavational point of view, the book is not so readable as, from the fascination of the subject, might be expected, but its solidity and thoroughness are apparent, and should appeal to all who take the slightest interest in archaeological discovery.

The description of the excavations of the great mound of Kouyunjik falls into two parts. In the first chapter a brief sketch is given of the work of Rich, who made his map of Nineveh in 1820, but unfortunately died the next year; of Botta and Layard. Botta, disappointed with his work on Kouyunjik, transferred his energies to Khorsabad, with the results so well known. Layard was more successful and astonished the world by his discovery of the palace of Sennacherib with its sculptures and library. After Layard finally left Nineveh in 1851, his work was continued by his assistant, Hormuzd Rassam, who discovered the palace of Ashurbarnipal, and thousands of cuneiform tablets. Unfortunately, his exploration of the palace had to be discontinued in 1854. In the second part are described the explorations since Layard's time. For twenty years after Rassam nothing was done. Then that brilliant genius George Smith came upon the scene, and excited extraordinary interest by discovering on the tablets the Chaldean account of the Deluge. Smith carried out excavations in 1873, 1874, and 1875, making further discoveries until his untimely death at Aleppo in 1875. With the exception of some clearing work, and collection of MSS. by Sir E. W. Budge in 1891, there were no further excavations of the site until 1903, when L. W. King, of the British Museum, reopened them. He further explored the palaces of Sennacherib and Ashurbarnipal, and sank many deep shafts revealing five different levels. In 1904 one of the authors, Mr. C. Thompson, was sent out to join and relieve King. He found traces of a new palace in the eastern part of the mound, and discovered the site of the Temple of Nabu. This work was discontinued in 1905, and the intervention of other interests and the Great War prevented any further exploration until 1927–28, when the authors returned to Kouyunjik and completed the excavation of the Temple of Nabu. They also explored the house built by Sennacherib for his son on the eastern side of the mound. Two interesting finds were made here, viz. a prism of Esarhaddon giving a complete account of what happened after the death of Sennacherib, and deep down a larnax burial containing a skeleton with a bronze bowl probably of the ninth century B.C. The skull was examined by Mr. D. Buxton without, as might be expected, any definite conclusion.

After describing the condition of Mosul and its neighbourhood at the present

time, with an appreciation of the sensible and considerate attitude of the 'Iraq Government towards explorers, most favourably contrasting with that now adopted by the Government of Egypt, the book concludes with a brief history of Nineveh. When the reign of Ashurbarnipal is reached the opportunity is taken of describing the library associated with his name, and the material on clay tablets and prisms. Some 19,000 tablets and fragments come from the Library, on which almost every class of literary effort is preserved. These now form one of the treasures of the British Museum. Soon after Ashurbarnipal's time, in the year 612 B.C., the city was taken and destroyed. During the following centuries little or nothing is known of Nineveh. The Assyrians seem to have been wiped out of history in an unexampled manner. When Xenophon's ten thousand passed by, Nineveh was apparently as much a ruin as to-day, and there is only very meagre evidence of civilized reoccupation down to the Christian era.

The book is illustrated with five plates of photographs of the mound and excavations, and eight plans of Nineveh, Kouyunjik, the palaces of Sennacherib and Ashurbarnipal and the Temple of Nabu. It would have been an advantage if a map of Mosul and the surrounding country had been added. There is an index, and the type is large and clear. E. A. P.

OUTLINES OF THE ANTHROPOLOGY OF THE TIMOR ARCHIPELAGO. By H. J. T. BIJLMER, with an Appendix by K. SALLER. (Indisch Comité voor Wetenschappelijke Onderzoekingen. Publ. III.) *Weltevreden, D.E.I.: G. Kolff & Co.* 1929. 11×7 *inches;* 234 *pages; illustrations and sketch-map*

The Government of the Netherlands Indies has long paid commendable attention to the anthropological study of the native populations under its rule, and the present treatise on the inhabitants of Sumba, Flores, and Timor, the three largest islands of the Timor Archipelago, was undertaken by Government direction and at the request of the Indian Committee for Scientific Research. There had been no serious anthropological expedition in this part of the archipelago since that of Dr. H. Ten Kate in 1890, a time when the islands were still unsettled, so that little detailed investigation could be done; Dr. Bijlmer's study is therefore both timely and valuable, since it is in this part of the Dutch East Indies that Indonesian and Melanesian stocks mingle.

Dr. Bijlmer, who is a medical officer in the Netherlands Indian Army, has been thorough and methodical, and obtained a general survey by examining groups of individuals at nine chosen centres on the three islands; these he measured, described and photographed. The results are contained in the present volume, which is a translation (indifferently done) from the original Dutch. It is a work mainly for the student or the scientist, to whom Dr. Bijlmer's data and carefully reasoned conclusions will be of great importance. O. R.

DE RETOURVLOOT VAN PIETER DE BITTER (1664–1665). By J. C. M. WARNSINCK. *The Hague: Martinus Nijhoff* 1929. 10×7 *inches;* viii+136 *pages; illustrations and map.* 7.50 *fl.*

This book gives us a most interesting account of the homeward voyage of a Dutch East India fleet of eleven ships which left Batavia on Christmas Eve 1664. Owing to the outbreak of war with England in the spring of the following year, they were forced to take refuge in the neutral harbour of Bergen in Norway, then under Danish rule. A more than discreditable plot was formed between the Danish King and the English Ambassador at Copenhagen whereby the Danes were to allow the English to attack and seize the Dutch ships in Bergen, and then divide the plunder—worth over 300 "tonnen" of gold—between them. Owing to a comedy of errors, however, the plot miscarried, and the English

attack was heavily repulsed by the Dutch under their gallant commander, Pieter de Bitter—one of Holland's lesser-known naval worthies whom Commander Warnsinck now restores to his rightful place in history. De Ruyter then appeared at the head of the Dutch Fleet—now reconditioned after its shattering defeat off Lowestoft in the June of the same year—to convoy the merchantmen home to Holland. Whilst off the Dogger Bank the fleet was scattered by a storm, and two of the Dutch Indiamen—the *Phoenix* and *Slot van Hooningen*—fell into the hands of the English. The immensely rich lading of these two vessels caused much joy in England at their capture, as can be seen from the interesting entries in the diaries of Pepys and Evelyn. However, Lord Sandwich, the commander of the English Fleet, and some of his officers were accused of misappropriating certain of the treasure for their own use, and a great outcry was raised which ended in Sandwich being temporarily disgraced. It is also interesting to note that five years later, in 1670, the Directors of the East India Company were trying to trace some valuable papers on the secrets of the Japan and China trades which had been captured aboard the *Slot van Hooningen*. Pepys and Arlington were mentioned as having got possession of some of these papers, and the E. I. C. were desirous of buying them in view of their forthcoming—and, as it proved, abortive—attempt to reopen trade with Japan in 1672–3.

The book is written in a singularly readable style, with numerous amusing quotations from contemporary authors which recall the heyday of English prose in that "laughing, quaffing, merry, drinking and unthinking time" of "Good King Charles' golden Days." Although the main part of the work is written in Dutch, many of the documents printed in the Appendices are in English, and from these alone a good idea can be obtained of what really took place at Bergen. But the book does not deal with the battle of Bergen only. The voyage from Batavia to the Cape, the lading and value of the Dutch Indiamen of the seventeenth century, and many other matters of maritime and geographical interest are dealt with. The book is remarkably well illustrated with excellent reproductions of contemporary drawings and prints; the beautiful seventeenth-century chart of part of the Norwegian coast at the end of the book is particularly worthy of notice as a splendid specimen of the fine old Dutch topographical work of the period. The book is printed and produced in a most attractive manner fully worthy of the enterprising publishers. No student of our wars with Holland or of our maritime history should miss this work. C. R. BOXER.

BANTU, BOER, AND BRITON. The Making of the South African Native Problem. By W. M. MACMILLAN. *London: Faber & Gwyer* 1929. 9×6 *inches;* xiv+328 *pages, and map.* 21*s*

As in the 'Cape Colour Question,' to which the book now noticed is a sequel, Mr. Macmillan, Professor of History at the University of the Witwatersrand, is concerned to bring home to white South Africans the danger of "settling" the native question by definitely classing the natives as an inferior race (or races). This is, in fact, a view widely held in South Africa, in direct contradiction to the declaration of Cecil Rhodes in favour of "equal rights for all civilized men south of the Zambezi."

From a different angle, and by an intensive study of the period of the Kaffir wars, Mr. Macmillan reaches conclusions very similar to those reached by Mr. de Kiewiet, another Witwatersrand University man, in his book reviewed in the *Journal* for June last. The native problem is twofold: economic and political. The economic problem arises from the dispossession of the natives from their land, and this is the great sin of the whites; fewer than half the natives of the Union are accommodated in the reserves. The political problem concerns the

franchise. There is, says the author, no "solution" in any policy which denies to the "little group of progressive and dispossessed Bantu, when and as they attain to civilization, full rights of citizenship in the Union which is their only home." Certainly of late years Boer and Briton in South Africa have not lacked warnings from prophets in their own country of the dangers ahead in mishandling native affairs.

The bulk of the book, as indicated, deals with the Kaffir wars down to the final defeat of the Amaxosa. The author draws largely on the unpublished papers of the great Dr. John Philip, and he is much to be thanked for the new light he sheds on a vital period of South African history. The policy of Dr. Philip is shown to have been much more sane and far-seeing than historians have hitherto admitted. He acted both with caution and moderation, and it would have been well for South Africa if his advice not to eject natives from conquered land had been heeded. The Transkei stands as a monument to the wisdom of Governor Sir Philip Wodehouse in keeping out the white settler.

In the account of Bantu tribal institutions it is made clear that the military despotism exercised by the Zulu and some other chieftains is not the normal form of government among the Bantu. They are a freedom-loving and democratically governed people, not very closely knit, and tribes tend, or tended, to split and form new groups and combinations.

A map of South Africa as it was known about a century ago is given, and is welcome. Still more welcome would have been a series of sketch-maps illustrating the successive Kaffir wars. F. R. C.

THE CRUISE OF THE *NORTHERN LIGHT*. By Mrs. J. BORDEN. *New York: The Macmillan Co.* 1928. 9×6 *inches;* xii+318 *pages; illustrations and map.* 18*s*

LOG OF THE AUXILIARY SCHOONER YACHT *NORTHERN LIGHT*. Borden-Field Museum Alaska–Arctic Expedition 1927. *Chicago: Privately printed* (*R. R. Donelley, Lakeside Press*) 1929. 12×9 *inches;* (360 *pages*); *illustrations and sketch-map*

The *Northern Light* is a two-masted auxiliary schooner which was built at Oakland for the Alaska–Arctic expedition sent north in 1927 under the command of Lieut.-Com. J. Borden by the Field Museum of Chicago. The main object was to collect specimens of large mammals for the museum, including the Alaskan brown bear, the polar bear, and the walrus. The expedition was away six months in the Bering Sea, Bering Strait, and on the coasts of Alaska and North-Eastern Siberia. There is an interesting glimpse of Wrangel Island, where the expedition hunted bears on the ice off the eastern end and sighted the Soviet settlement, but did not land. The course lay near Herald Island, but no landing was made, and it was decided that in spite of certain appearances from a distance there is no new land immediately to the south of that island. Mrs. Borden has written an entertaining volume, with here and there a spice of adventure. She contrives to give a good deal of information and to draw a vivid picture of life in Alaskan outposts and of the Chukchis of North-Eastern Siberia. The illustrations are well chosen and there is a rough track chart printed inside the covers.

The ship's log has been printed as a distinct volume, on beautiful paper in fine black and red type and well bound in linen. As an example of typography and bookbinding it merits high praise, but it is difficult to understand why the log of a vessel which was not an exploring ship needs to be perpetuated in an edition-de-luxe of one hundred signed copies. The only chart is a rough sketch. R. N. R. B.

DEPOPULATION IN THE ALPS

The concentration of population in large urban groups—"the flight from the country"—has been in progress for at least fifty years, and in most countries, in the New, as in the Old, World. There exists therefore a large mass of material for the study of a condition which is still acute. In "Studien zur Gebirgsentvolkerung" (*Beiträge zur Agrargeographie*, No. 4: Bern 1928) this question is studied in general, but more particularly for mountain districts, with special reference to Switzerland. It may be noted at once that the causes of mountain-depopulation do not differ in kind, but in degree only, from those of rural decline in general. The mountain areas are on the margin of existence, and consequently suffer first and most severely from disturbances in the economic system. Switzerland, in part a densely populated industrial area not easily accessible to foreign supplies, has a special interest in keeping land in cultivation, but there is a definite limit to the measures to be taken to support a rural population at the expense of the towns. The volume opens with a general survey of the world problem by H. Bernard, who shows that it is not entirely economic, but that social and psychological influences are at work. This is recognized by most governments, who are combating it by the improvement of social and recreative opportunities as well as of technical and educational facilities. The main difficulty is in keeping the standard of living on the same level as in industrial centres, and not merely in preventing an absolute decline. In England, however, and other European countries, the main cause of decline has been the competition of the New World grain, in the face of which many of these counter-remedies can have little result.

In the second study, A. Koller examines the geographical basis of depopulation in the Alps, using the returns for the six censuses between 1860 and 1920. There are very few of the communities which do not show a decline in one census period at least, and equally few which have declined throughout. The areas of depopulation are chiefly in the Eastern and Central Alps: in the east, the valleys of the Lech, the Upper Inn, and the Kaunser, the highlands between the Etsch and Sarn, and the valleys tributary to the Etsch. In the Central Alps the areas of depopulation are more extensive and the process more intense, some showing decrease for five or six of the six census periods: these are the upper valleys of Graubünden, Ober-Wallis, and the Maggia and Verzasca valleys of Ticino. In the Italian Alps the chronic areas are the Sesia and Doria Baltea valleys and all the valleys of the Western Alps. For the Alps as a whole the intensity of depopulation increases from east to west, and there have been two maxima, 1880–90 and 1910–20. From a study of the causes, it does not appear that geography plays a primary part. The long winter, during which small home industries are the sole occupation, has prompted seasonal migration: but the decisive facts are the destruction of the home industries by large-scale manufacture, and the attractions which turn this seasonal migration into permanent absence.

The third portion of this thorough report is probably of greatest value: it consists of the detailed results of a long and intricate questionaire which was directed to ascertaining the degree and reasons for depopulation in selected communities in all parts of Switzerland. In North-Eastern Switzerland, it may be attributed to the disappearance of the embroidery industry, which has brought about an absolute decline in the standard of living. Two small communities will show the conditions of the border-line units. Realp, in Graubünden, despite a continuous excess of births over deaths, has declined from 242 in

1860 to 192 in 1920. This is attributed to the lack of an additional source of income, the isolation of the village in winter, damages suffered from the flooding of the Reuss, and the necessity for sanitary improvements. Guttanen, Bern, has declined from 505 inhabitants in 1860 to 298 in 1920. Here 66 per cent. of the area is unprofitable, and the settlement has been harried by floods, avalanches, and fires. It appears likely, therefore, that the environment is altogether unprofitable. The proposed methods of fighting this tendency largely resolve themselves into government subsidies for the development of cooperation and insurance in agriculture, the improvement of communications and sanitation, the erection of hydro-electric plant, and the encouragement of home industries, or development as tourist centres, though it is recognized that the latter can be of mixed blessing from this point of view. A valuable series of maps which show the percentage decline in population of all "Gemeinde" for each census period completes the work.

A GERMAN ILLUSTRATED MONTHLY

We have received the first numbers, beginning in January, of a German illustrated serial, devoted to the more popular aspects of geography and travel, which is published by Ernst Wasmuth of Berlin, under the title *Atlantis*. For a magazine of the kind it makes a distinctly good impression, the contents being varied and well written, while the illustrations reach an unusually high standard. Apart from those liberally scattered throughout the letterpress, each number contains four pages of photogravures printed on special paper, some of which are of singular beauty. The subjects dealt with range from the castles on the Loire to the Amazon forests, and from excavations in Egypt to the search for the great meteorite which fell a few years ago in the wilds of Siberia. Serious exploration receives attention as well as the lighter side of travel. Thus the editor has secured interesting and fully illustrated communications from Dr. Emil Trinkler and his companion Herr W. Bosshard on different sections of the German Central Asian Expedition of 1927–28 to Western Tibet and Chinese Turkistan. The support now given by the public to such publications in various countries (in Italy, for example, a somewhat similar rôle is played by the well-known serial *L'Universo*) is an indication of the popular interest in their subject which has been aroused, and though similar undertakings in the past have not always been successful, the great progress recently made in methods of illustration gives an advantage to their successors and justifies the expectation that a well-produced magazine like that under notice will gain for itself an established position.

SEASONAL RAINFALL IN EUROPE

The main features of the mean seasonal distribution of rainfall in Europe, an excess of rain in summer in the east and centre, in autumn in the west, and in winter in the south and on the Atlantic fringe, have long been known, but the subject is studied in greater detail in a recent paper by Dr. J. Glasspoole in the *Q.J.R. Meteor. Soc.* (vol. 55), with maps embodying percentage figures. The western and southern countries have more rain in the winter half-year (October to March) than in the summer (April to September), the central and eastern more in the summer, the 50 per cent. line for each half-year protruding south-westwards, however, into France. The seasonal quarters adopted are: winter, December, January and February; spring, March–May; summer, June–August; and autumn, September–November; a grouping which for this particular purpose is probably the best. The winter excess on this basis in the extreme south of Europe is represented by 45 per cent. of the annual total; the

autumn excess in the west by 30 per cent.; and the summer excess in the extreme east by 40 to 50 per cent. The summer rains in Central and Eastern Europe are of convectional origin, whereas the summer drought over the Mediterranean basin is due to the extension northwards of the Trade Wind regimen. The autumn (October) maximun of rainfall in the West, which is chiefly confined to England and France, would appear to be due to the influx of warm, moist Atlantic winds interacting with colder air from the Continent, which at that season is cooling rapidly. The winter excess in December or January along the Atlantic fringe, namely the Western parts of the British Isles and Norway, appears to be fundamentally an orographic effect when the south-west winds are strongest. The high central plateau of Spain has most rain (over 30 per cent.) in the spring and autumn quarters of the year. This is a feature that frequently puzzles students; but it was suggested by the writer of this note, in the discussion after the paper, that it is really a passive result of the fact that Spain is kept dry in winter by Continental high pressure and in summer by Atlantic high pressure. Spain, by its local geographical conditions ought to have a heavy summer rainfall of monsoonal type, and the fact that this tendency is overridden by the dominating influence of the Atlantic high pressure is an instructive illustration of the principle that local factors have to compromise with general factors in the circulation of the atmosphere.

In the British Isles the seasonal distribution when examined in detail is found to be highly complex, since the factors tending to produce summer, autumn and winter excesses of rain to some extent overlap. Thus whereas over the bulk of England the autumn maximum holds, the winter maximum appears in Devon and Cornwall, whilst the Central European influence is shown in a very pronounced secondary maximum in midsummer over East Anglia. A late summer(August) maximum in Northern England and Southern Scotland results from cyclonic activity at a time of year when the temperature and humidity are high.

TRACES OF GLACIATION IN NORTHERN ASIA MINOR

We have received from Madame Czeczott, widow of the late Professor Czeczott of the Botanical Institute of the University of Cracow, a note stating that when crossing the Ilghaz Daghi range in Northern Asia Minor in 1925 she found what she believes to be traces of ancient glaciation. When climbing Bryuk Ilghaz Daghi, the highest peak in the range, on the slope opposite that facing the Angora–Ineboli road, she was struck by the presence at about 2000 m. altitude of a number of parallel walls, which appeared to follow the contour-lines of the slope. These walls were from 2–3 metres in height, covered an area of several kilometres, and were overgrown by pine trees. Madame Czeczott suggests that they are possibly the remains of the terminal moraines of ancient glaciers, and she wishes therefore to draw the attention of geomorphologists to the Ilghaz Daghi range, as traces of ancient glaciation have been known till now only from the Mysian Olympus, and have been proved in no other part of Northern Anatolia.

THE MAJOR WORLD SOIL-GROUPS

A brief but valuable study of this subject has been contributed by Mr. L. A. Wolfganger, of Columbia University, to the *Geographical Review* for January 1929. The development of the study of soil science in recent years has been rapid both in the U.S.A. and Europe, and the author gives from the American point of view some interesting suggestions for the division of the world into major soil-groups and their relation on the one hand to known facts of economic geography (such as food supply), and on the other hand to climate. He claims that

far more attention should be paid to the chemical, physical, and biological properties of the soil itself than to its parent material or the actual method of accumulation, since the texture, colour, structure, and chemical composition of the soil all unite in determining its value for agriculture, and this is its most important aspect. Of these, structure is exceedingly important, for on it depends the response to fertilizers and the final output when utilized for crops. He emphasizes the fallacy of regarding soils as necessarily having the fundamental characteristics of the parent rock. He instances the variety of soils which may be derived from loess, and conversely the uniformity of soils in the group known as *chernozems* (black earths), although these may be derived from a large variety of parent rocks, ranging from granite to loess. With European pedologists the author agrees that climate is the most important soil-forming agent. Uniformity of climate tends to produce uniformity of soil, though soils vary in age (and therefore in formation), as they may be young, mature, or old.

Basing his divisions on the dominant mature soils of each group, he suggests the following seven major groups, the first four being non-lime accumulating, and the last three being lime-accumulating, soils :

A. *Non-Lime-accumulating Soils.*—(*a*) *The Laterites*, which are characteristic of the hot steamy areas of the tropics. They are not primarily good for commercial agriculture, but future development might result in their supporting a fairly dense population on low-latitude crops. (*b*) *The Podsols*, which constitute the dominant whitish or grey soils of the northern coniferous forests. This term is adopted from the Russian (meaning ashy). They are acid and deficient in organic matter. Manuring is essential if they are to produce well. At present they are largely under potatoes, rye, and barley. (*c*) *The Red Earths*, which form soils in middle latitudes. They are in some ways akin to the podsols and in others to the laterites. (*d*) *The Grey-Brown Earths*, which characterize the cool humid lands of North-Western Europe and the North-Eastern United States. They develop under deciduous forest covers, are low in lime-content and moderate in fertility. They are good in structure. With ample manuring, large crops of grains, roots, hay and fruits can be raised and a large population supported.

B. *The Lime-accumulating Soils.*—(*e*) *The Chestnut Earths*, which characterize semi-arid regions. Specialized farming methods are necessary if crops are to be a success. (*f*) *The Grey Earths*, which constitute desert areas where the surface is pebbly, sandy, or rocky. Little life is supported except in oases. (*g*) *The Chernozems*, which constitute one of the most striking groups in the world. They attain enormous extent in Russia. They are wonderfully rich and produce vast quantities of grain, especially wheat. Their structure is excellent: they are deep and full of organic matter: hence their name (black earth).

Finally, a special division is suggested for the rich prairie earths of the Mississippi Valley, which bear some resemblance to chernozems.

The whole paper is valuable for its clear summary of the main characteristics of these divisions, and one feels that it clears the way for the further detailed discussion which is essential to soil study. One minor objection must however be raised. To an English eye the spelling of red-earth or prairie-earth as "rederth" or "prairyerth" seems very odd.

THE SEA-WAVES OF THE MEXICAN EARTHQUAKE OF 16 JUNE 1928

A recent number of the *Monthly Bulletin* of the Hawaiian Volcano Observatory (vol. 16, no. 6) contains a brief but interesting article by Mr. R. M. Wilson on the sea-waves that accompanied the Mexican earthquake of 16 June

1928. The epicentre of the earthquake lay in lat. 14·5° N., long. 96·8° W., or in the Acapulco Deep about 125 miles from the south coast of Mexico. Sea-waves were observed at various places along the coast. In the Hawaiian Islands they were recorded at Honolulu and Hilo. At the latter station the range of the largest movement was 1 foot 4 inches, and the curve, the more important part of which is reproduced, shows that the oscillations of the water-level lasted for more than 24 hours. The first movements reached Hilo in 8 hours 29 minutes after the earthquake, having traversed the intervening distance of 3860 miles at the mean rate of 455 miles per hour. On 22 March 1928 a similar, but less violent, earthquake occurred in almost the same origin, but if any sea-waves were produced they left no trace on the Hilo mareogram.

INTERNATIONAL MAP OF THE ROMAN EMPIRE (1/M)

At the International Geographical Congress at Cambridge last year, the proposal, made in a paper read by Mr. O. G. S. Crawford, was adopted that a map should be published of the Roman Empire, based on the International 1/M map of the world. A special commission was appointed, with Brigadier Jack, Director-General of the Ordnance Survey, as President, and Mr. O. G. S. Crawford as Secretary. This commission held its first meeting in Florence on April 30 and May 1 this year. Representatives of Italy, Spain, and Great Britain were present and the general character of the map decided upon. A report of the conclusions reached has just been published. The first edition of the Ordnance Survey Map of Roman Britain was adopted as a general model. The area to be covered was fixed as that of the Roman Empire at the time of its greatest extent, the time ranging from the first appearance of the Romans in each region down to the fall of the Western Empire. In compiling the map the sheet of the 1/M map is to form the unit in each case, and the Commission hopes to arrange for the printing and publication of each sheet by the Government responsible for the corresponding 1/M sheet. A list of the 1/M sheets which will make up the map, with the name of the country whose government is responsible for their publication, is given in the report, as well as an index map.

The Commission recognizes that many difficulties will arise in selecting the features to be shown on the map, but points out that it is of first importance to keep the map as clear and simple as possible. Further, the aim of the map is historical and not archaeological—to show the distribution and character of population, the names of towns and natural features, and the economic and social conditions of the period. Only Roman remains will be shown, and of cities only those inhabited during the Roman period, as defined above, or during some portion of it. The inclusion or omission of any site, however, will have to be decided on individual merits and not by any hard-and-fast rules. In addition to the names of inhabited sites, the Commission states that wherever possible the names of topographical features should also be shown. The ancient name will be engraved in characters based on those used on Trajan's column, and the modern name in italics beneath. A list of symbols adopted by the Commission is included in the report. Sheet North N 30 [Edinburgh] of the International series is being compiled as a type sheet in the same style as the map of Roman Britain.

The Commission hopes to have several sheets published before the next meeting of the International Geographical Union at Paris in 1931. Sheet North K 33, on which Rome appears, is already in preparation, and will be printed with other Italian sheets by General Vacchelli, Director of the Istituto Geografico Militare at Florence, on behalf of the Italian Government.

OBITUARY

DR. HERMANN WAGNER

Dr. Hermann Wagner, the *doyen* of German Geographers and for forty-three years an Hon. Corresponding Member of this Society, died on June 18 last, at the great age of eighty-nine years, having failed to complete his ninetieth year by only a few days. Earlier in the year he had undergone a serious operation, and though at first it seemed successful, he succumbed to the after-effects some weeks later.

Wagner was one of the stalwart band of geographers, of whom he was the last survivor, to whose credit must be placed the reform of geographical education in Germany during the latter part of the nineteenth century. Born at Erlangen in 1840, he came of a Franconian family of which various members rose to distinction, his father being the talented physiologist and anthropologist Rudolf Wagner, and his uncle the naturalist traveller Moritz Wagner. During his infancy his father moved to Göttingen as successor to Blumenbach, and he thus early began his long association with that city, broken only during seventeen years of early middle life. His early bent was towards mathematics, and to this and the allied subject of physics he gave special attention during his university career. In 1862 he joined the teaching staff at the Göttingen gymnasium, giving help also to his father in the latter's anthropological researches. In 1864 he was offered a post in the Gymnasium Ernestinum at Gotha, and thus came in contact with the noted firm of Perthes and its director Dr. Petermann, who introduced him to various distinguished travellers, while he also became known to men like Berghaus, Behm, and Vogel. A plan submitted by him to the Perthes firm for a systematic elementary Atlas was agreed to in principle, but never came to practical fulfilment, as the great undertaking of 'Stieler's Handatlas' stood in the way. In the same year he undertook the editorship of the statistical section of the 'Almanach de Gotha,' which he largely transformed during seven years' work. The statistical side of geography also claimed his services as joint author (first with Behm and later with Supan) of the series of critical studies on 'Die Bevölkerung der Erde' published as 'Ergänzungshefte' to *Petermanns Mitteilungen*, and another work of great importance was the re-calculation of the dimensions of the Earth in metric measure published in 1870.

As a teacher at the Gymnasium Wagner bent his energies to bringing the study of geography to the front, and he agitated (simultaneously with Kirchhoff and others) for the reform of geographical teaching throughout Germany. Such efforts at last bore fruit, and when in 1875 all the German Universities were opened to the subject, Wagner was proposed for the first Professorship at Königsberg. He took up the post in 1876, and for four years and a half worked assiduously at the task of training a band of geographers and teachers, which became the nucleus of an important school of geography in this part of the Empire. After Petermann's death in 1878 he became editor of the 'Geographisches Jahrbuch,' which in his hands developed into an invaluable bibliography of all branches of geography. He also took over the 'Lehrbuch der Geographie' of Guthe, which he recast and greatly extended in successive editions. In 1880 he was called to the chair of geography at his old home at Göttingen, resisting the counter-attractions of an offer of the similar chair at Leipzig, as also, some years later, of that at Vienna. Göttingen remained his sphere of work for the next forty years, his retirement finally taking place at the age of eighty, with mental and physical vigour still unimpaired.

During the earlier part of his life at Göttingen one of his most important works was the preparation of his 'Methodischen Schulatlas,' to which he had devoted several years before its publication in 1888. It soon became one of the standard Atlases in use in German schools and even in higher institutions. He also paid much attention to the history of geography and cartography, his studies on which were published mostly in the *Nachrichten* of the Göttingen Society of Sciences. The subjects treated of included the reconstruction of the famous Toscanelli map, the early "portolanos," and the use in the Mediterranean of a "lesser mile" in old days. He devoted special attention to the statistics of areas, and published an important work on 'Das Areal Europas.' In all his work he showed a well-developed critical faculty, and was great at method and organization.

For most of the above details we are indebted to a valuable sketch of his life by his former pupil Dr. W. Sievers, given (with portrait) in the ' Geographen-Kalender' for 1908. On his retirement from active work in 1920, addresses were presented to him, the one signed by eighty-two of the best-known German teachers of geography, the other by more than 800 old pupils and friends. These were printed in *Petermanns Mitteilungen* for that year, accompanied by a classified list of his principal writings, running to no fewer than 273 items.

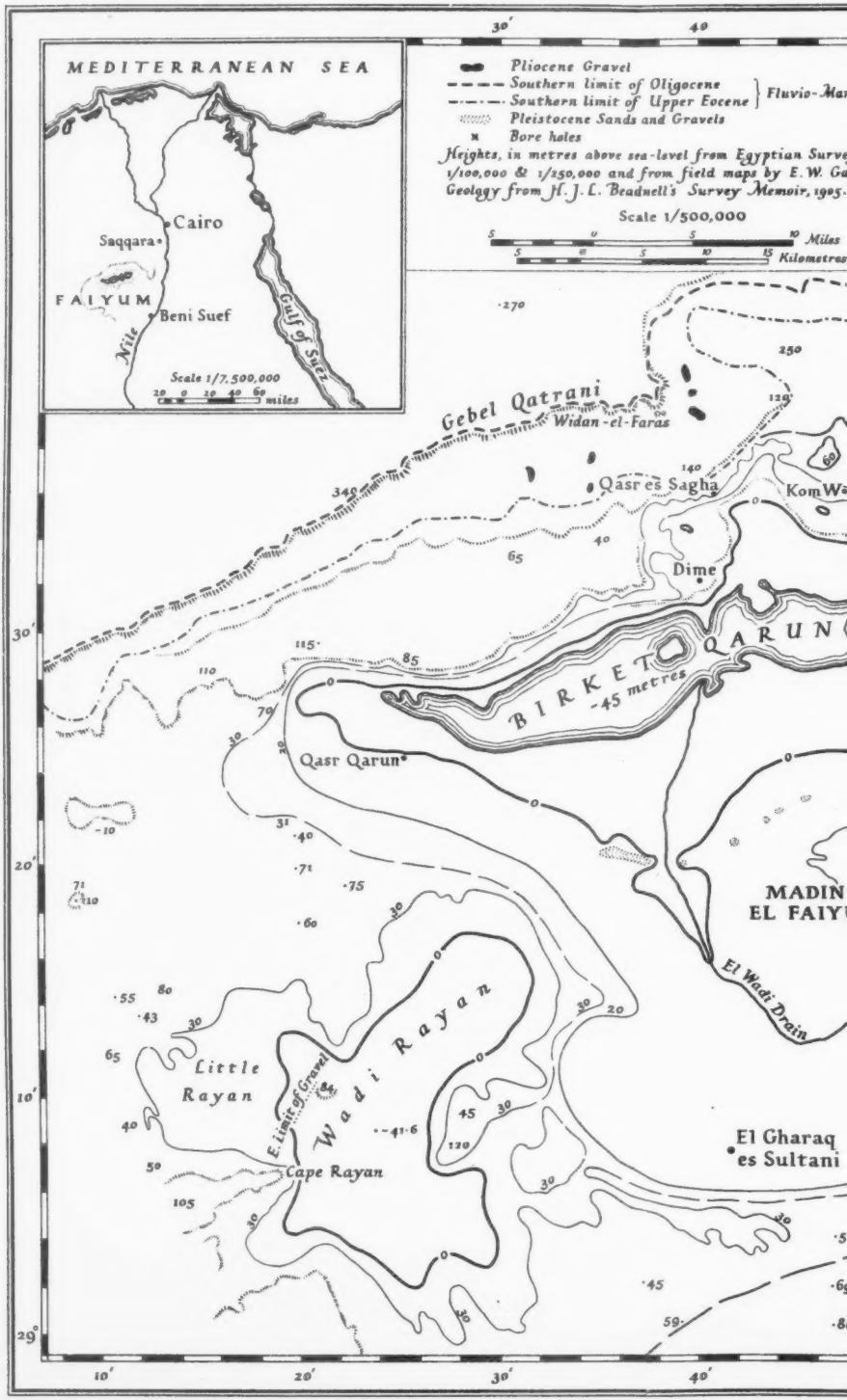
MRS. THEODORE BENT

We regret to record the death, early in July at the age of eighty-three, of Mrs. Mabel V. A. Bent, widow of the accomplished traveller Mr. J. Theodore Bent, whose archaeological and other explorations in Africa and Arabia attracted much attention towards the end of the last century, and were described in a series of papers read at the evening meetings of the Society. Mrs. Bent was his constant companion on these expeditions, sharing in all the dangers and hardships involved, and collaborating with him in the publication of their results. She herself contributed to this journal a preliminary account of the 1896 expedition to the Yafei and Fadhli countries in Southern Arabia, and her name appeared as joint author with Mr. Bent of the volume published in 1900, under the title 'Southern Arabia,' in which the various journeys in that unknown land were more fully described. She had survived her husband by thirty-two years, he having died at a comparatively early age in 1897.

MR. SAMUEL TURNER

We regret to learn the death of Mr. Samuel Turner in New Zealand at the beginning of August.

Mr. Turner was a well-known mountaineer, who had climbed in various parts of the world, such as the Alps, the Andes, the comparatively little-known range of the Altai, where he made several new ascents including the highest peak, to which, being hitherto unnamed, he wished to give the name of Willer's Peak, and more particularly in the New Zealand Alps, which he explored practically from end to end, making an especial study of the Tutoko group in the neighbourhood of Milford Sound. He has recorded his adventures in three books, 'My Climbing Adventures in Four Continents,' 'Siberia,' and 'The Conquest of the New Zealand Alps.' He was elected a Fellow of this Society in 1905.


MEDITERRANEAN SEA
Cairo
Saqqara
FAIYUM
Beni Suef
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Gulf of Suez
Scale 1/7,500,000
miles
Pliocene Gravel
Southern limit of Oligocene
Southern limit of Upper Eocene
Fluvio-Ma
Pleistocene Sands and Gravels
Bore holes
Heights, in metres above sea-level from Egyptian Surve
1/100,000 & 1/250,000 and from field maps by E.W. Ga
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-45 metres
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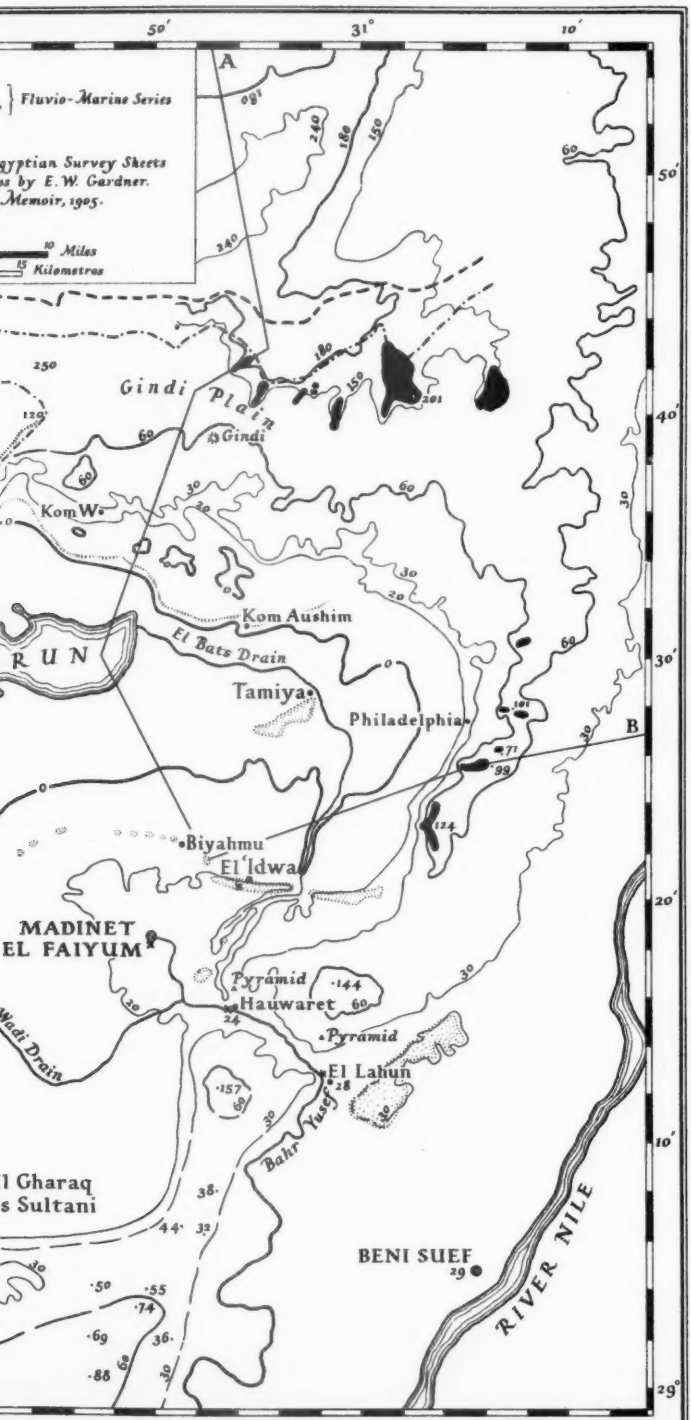
es Sultani
30'
40'
20'
10'
29°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A
B
Fluvio-Marine Series
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s by E. W. Gardner.
Memoir, 1905.
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Biyahmu
El 'Idwa
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EL FAIYUM
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Hauwaret
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El Lahun
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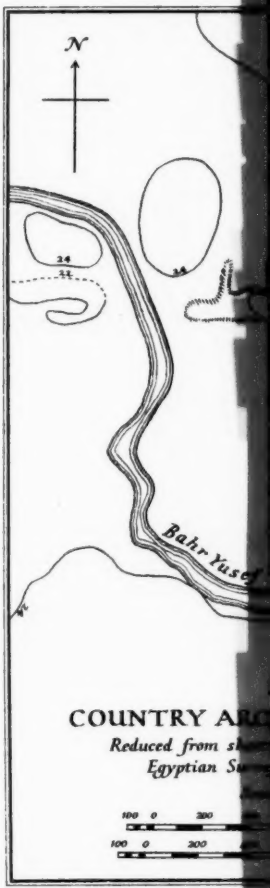
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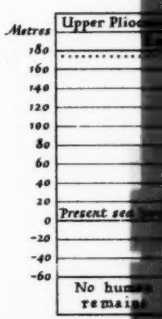
Metres
Upper Pliocene
180
160
140
120
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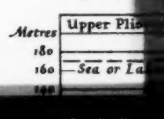
80
60
40
20
0
-20
-40
-60
Present sea
No human
remains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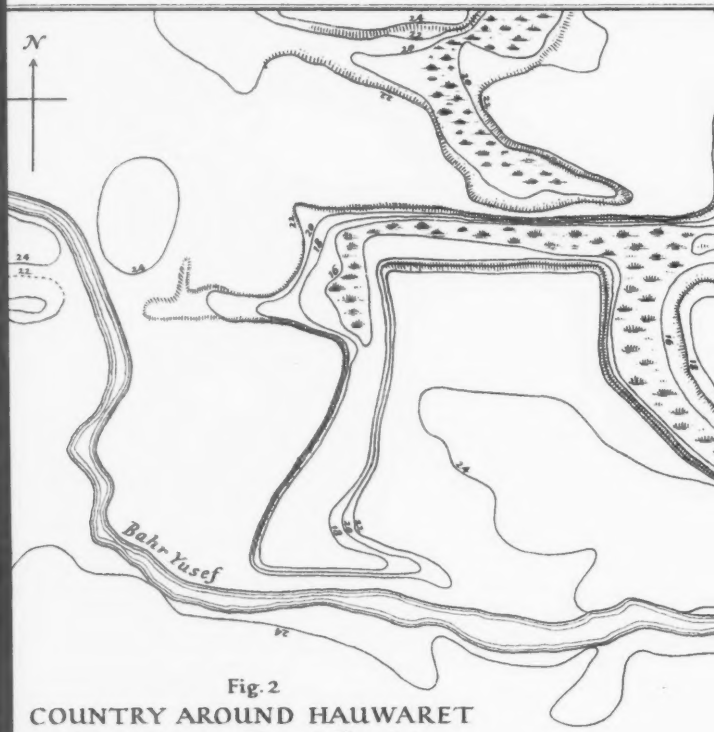

Fig. 2

COUNTRY AROUND HAUWARET

Reduced from sheets 124/600 C. and 125/600 C. of the Egyptian Survey on scale of 1/10,000.

Scale: 1/25,000

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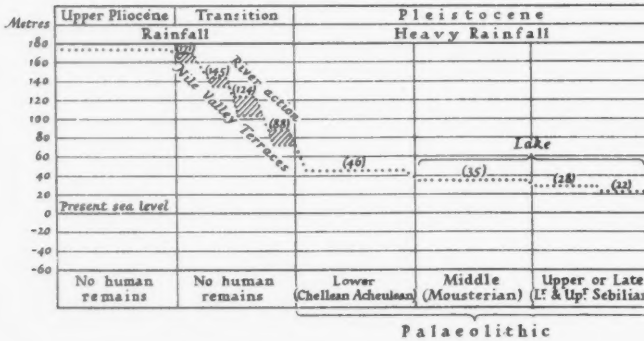
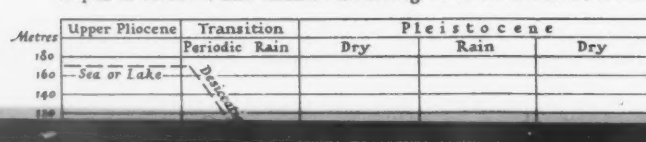
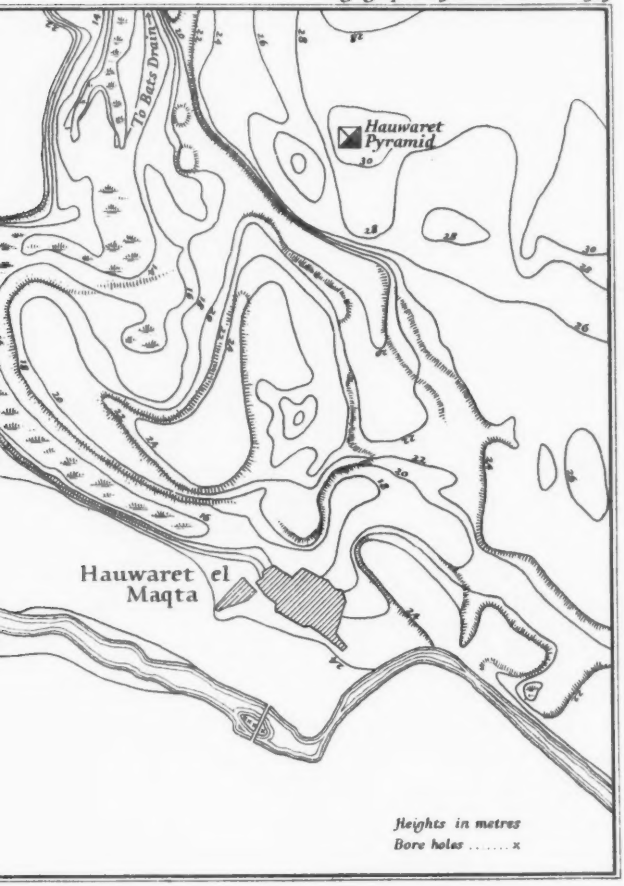
100 0 200 400 600 800 1000 Metres

Depth of erosion, and climate according to K. S. Sandfor



Depth of erosion, and climate according to H. J. L. Beadnell, G. Cat



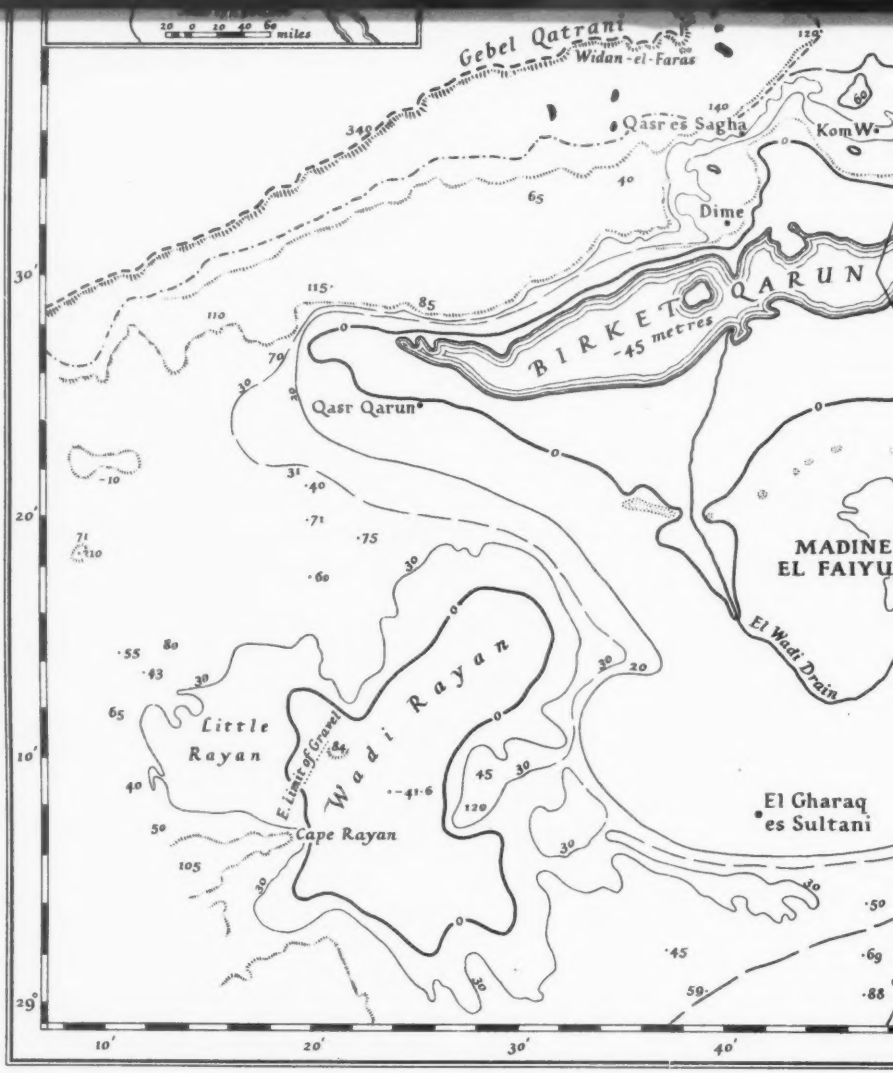


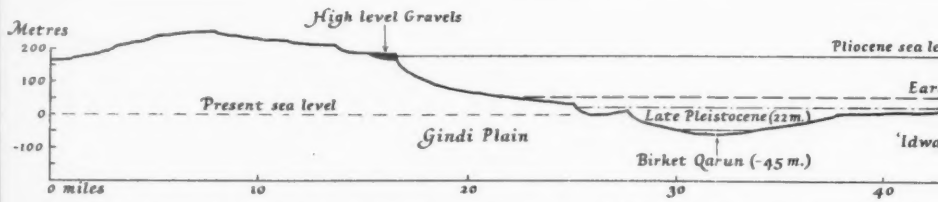
dford and W. J. Arkell.

	Transition	Recent	Geological Periods
		Desert	Climate
			..... Depth of erosion
(22)	River action		
or Late Sebilian		Neolithic	Human Periods in Egypt

G. Caton-Thompson and E. W. Gardner.

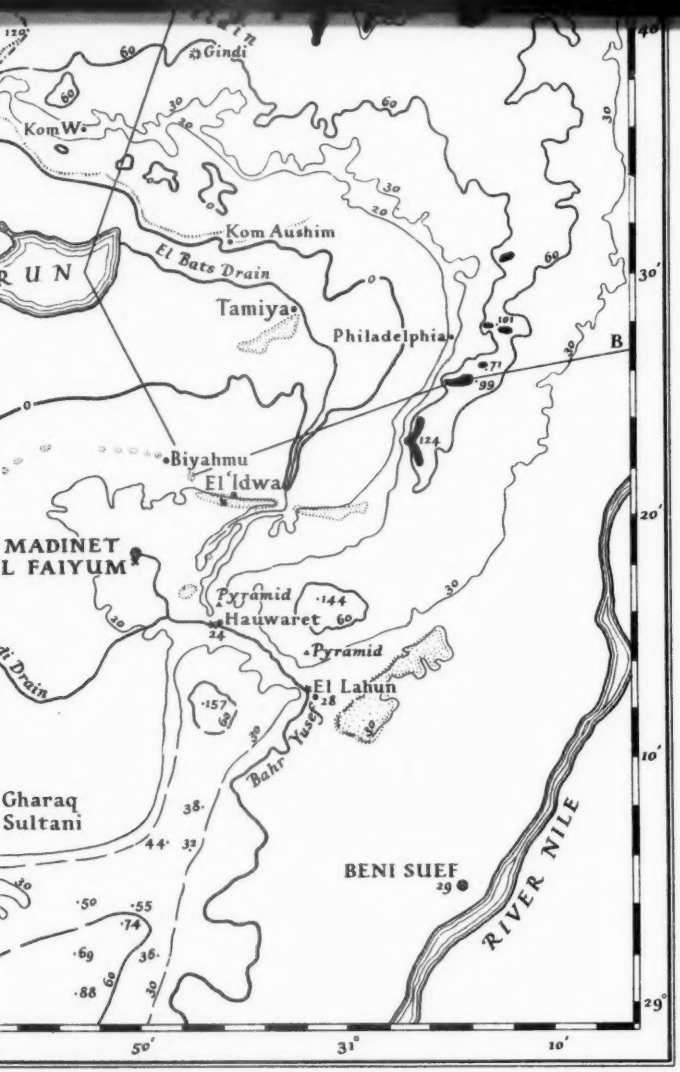
	Transition	Recent	Geological Periods
y	Rain less than in Middle Palaeolithic.	Dry with many rain at (16), (4) and (-2).	Climate
			..... Depth of erosion.

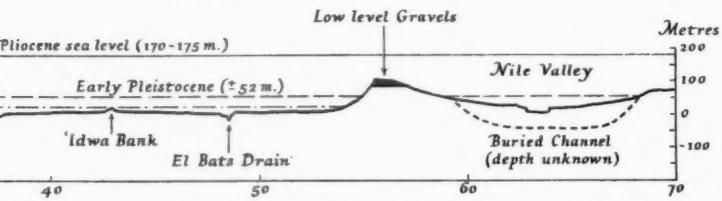




Section from A to B with a continuation to the Nile Valley to show the rela
levels of erosion according to Drs. Sandfor

Fig 1. THE FAIYUM DEPR

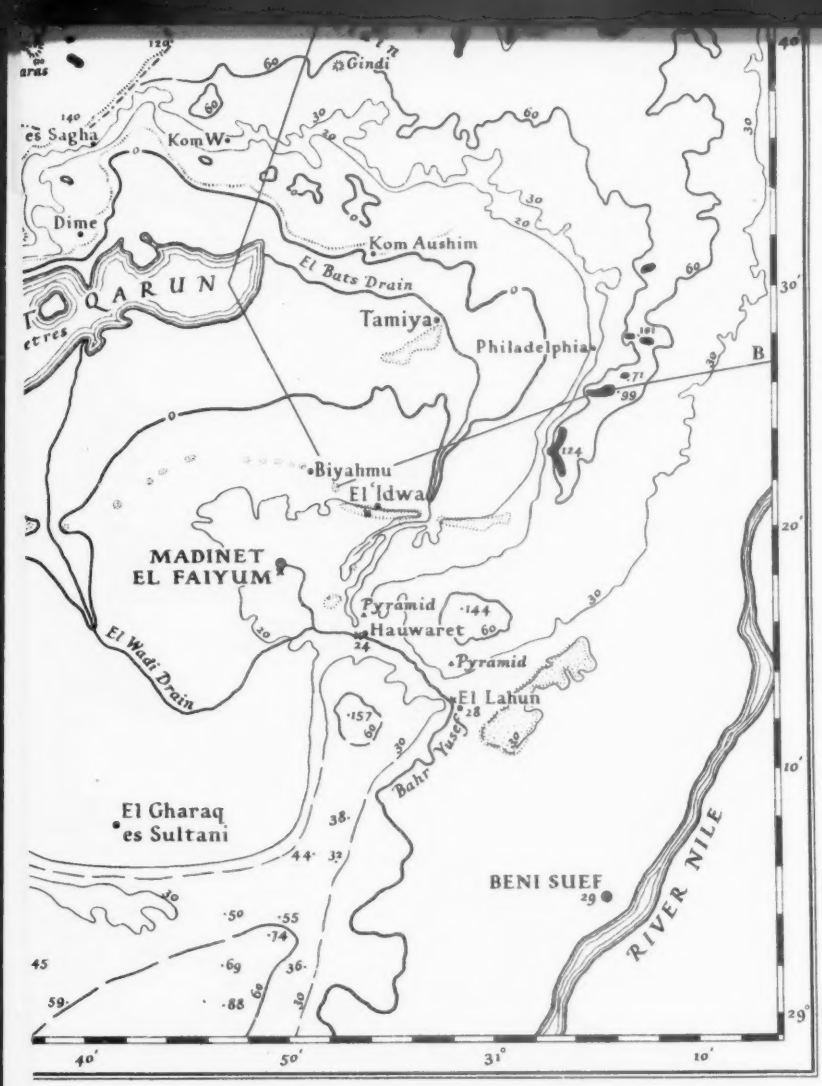


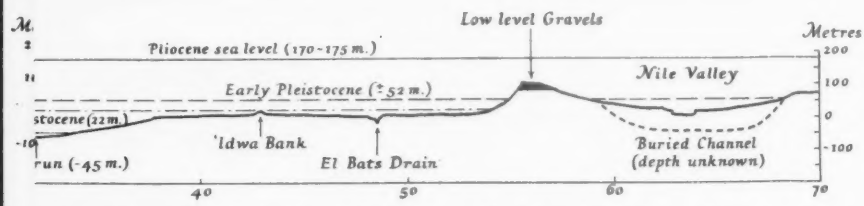


w the relation of the high and low level Pliocene Gravels and
rs. Sandford and Arkell.

DEPRESSION.

Published by the Royal Geographical Society





lley to show the relation of the high and low level Pliocene Gravels and rding to Drs. Sandford and Arkell.

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Published by the Royal Geographical Society

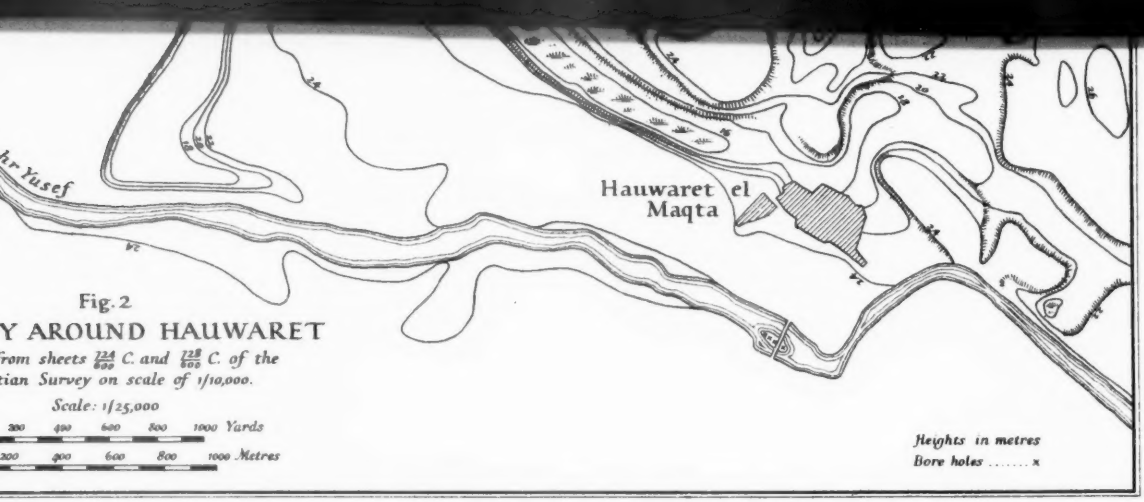
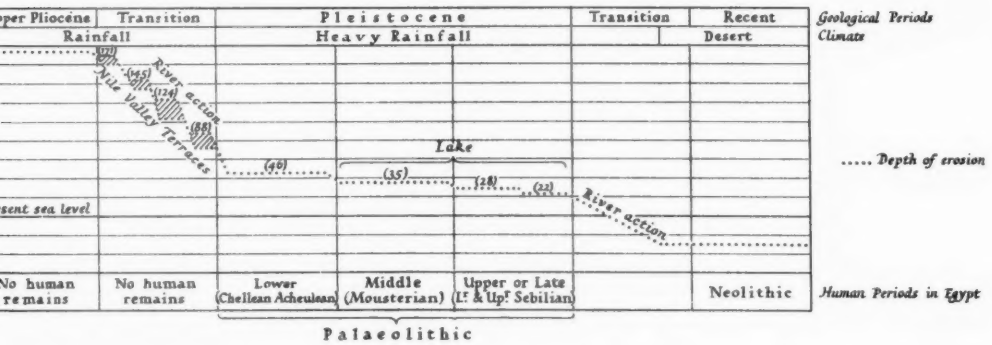


Fig. 2

Y AROUND HAUWARET

rom sheets 124/600 C. and 128/600 C. of the tian Survey on scale of 1/10,000.

Depth of erosion, and climate according to K. S. Sandford and W. J. Arkell.



pth of erosion, and climate according to H. J. L. Beadnell, G. Caton-Thompson and E. W. Gardner.

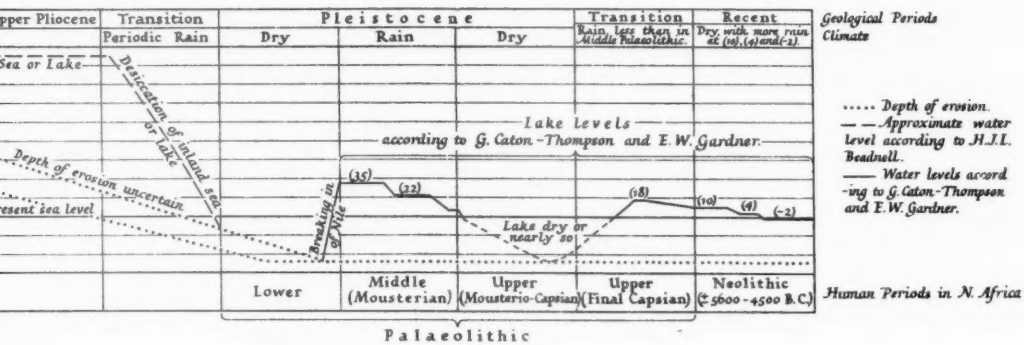


Fig. 3

Note :– *No attempt has been made to indicate the relative lengths of the different periods in either graph, the transitional and recent periods were probably shorter than the others, the Pliocene possibly longer.*

U. OF MICH.

The

C. H. KAR

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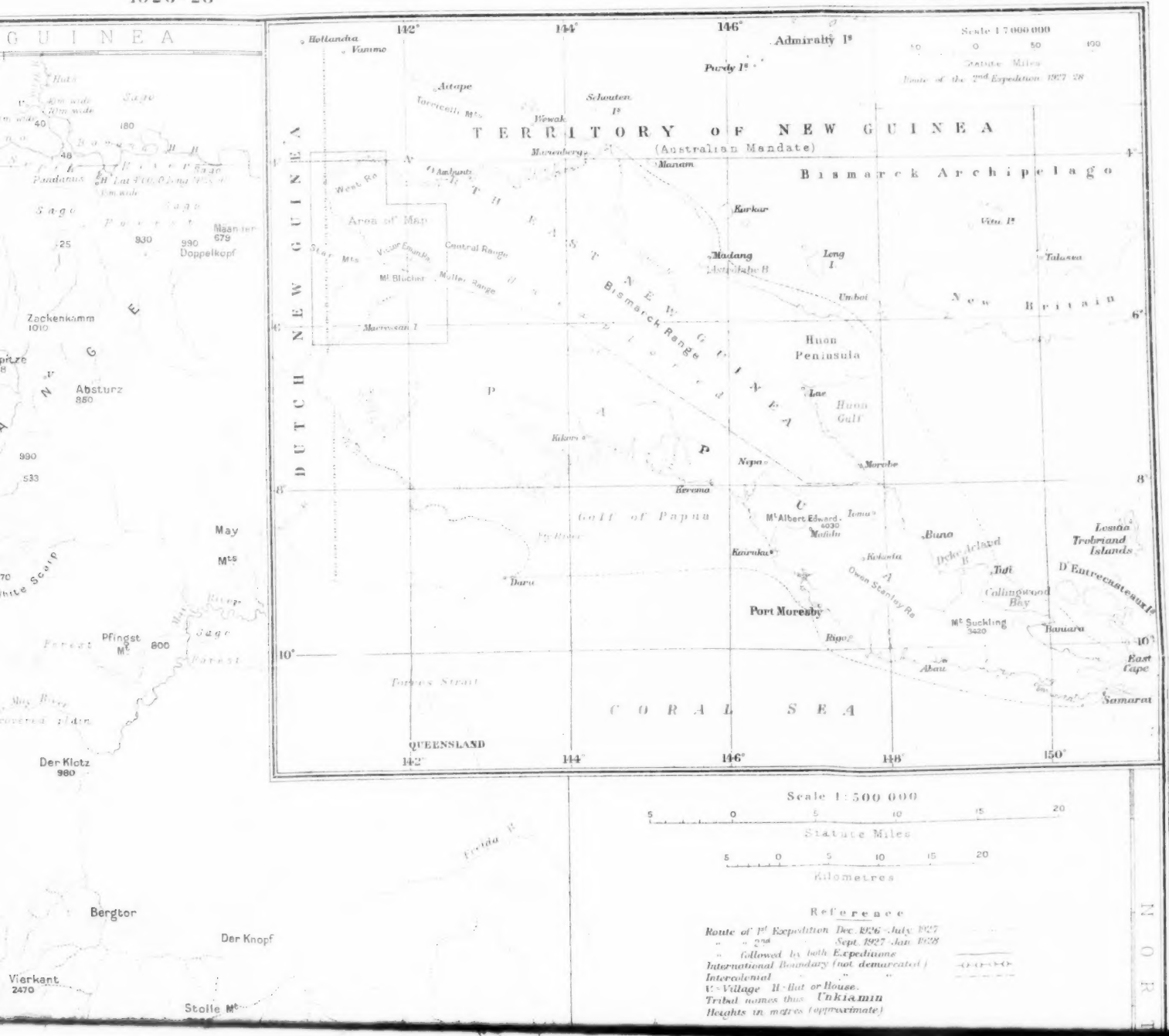
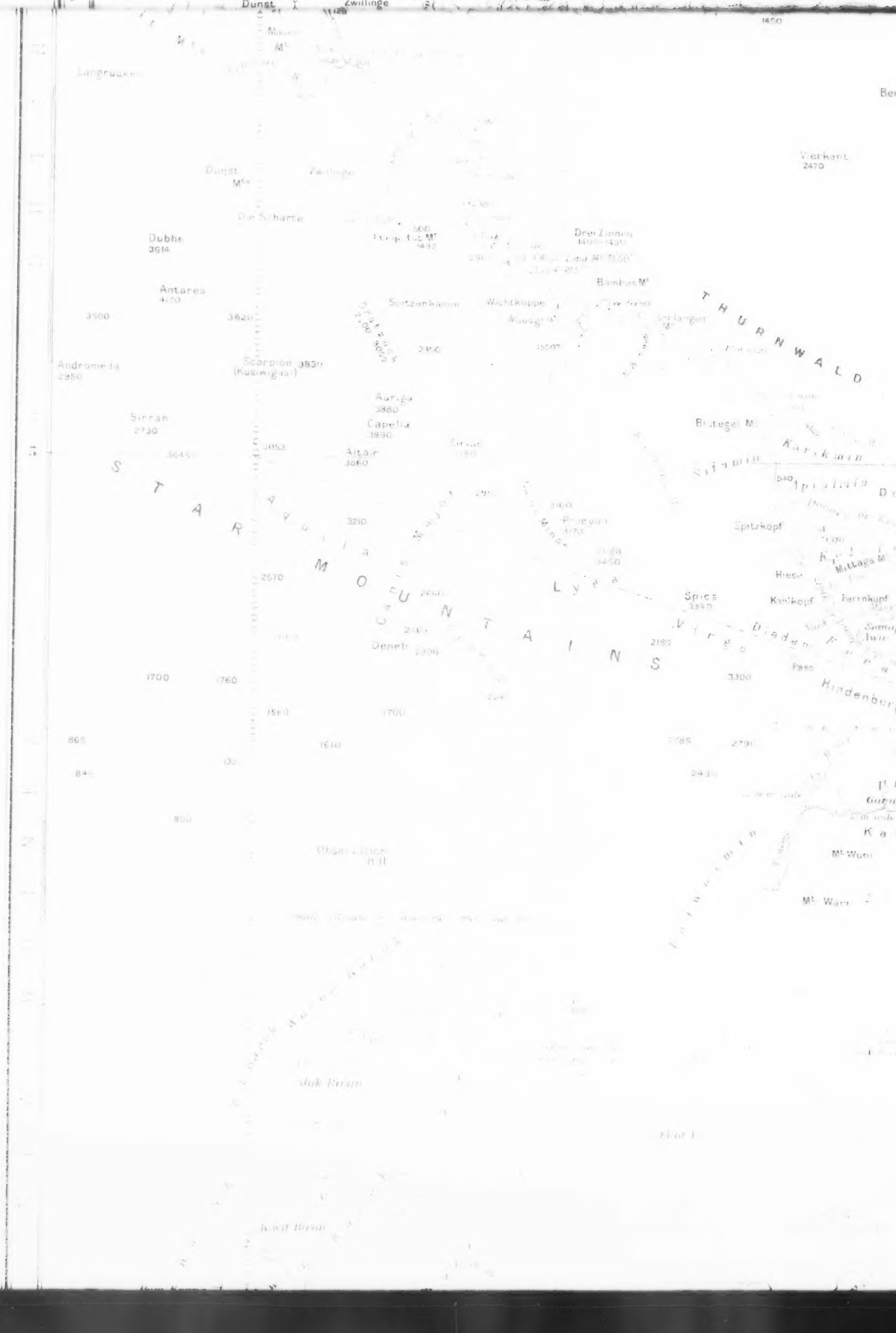
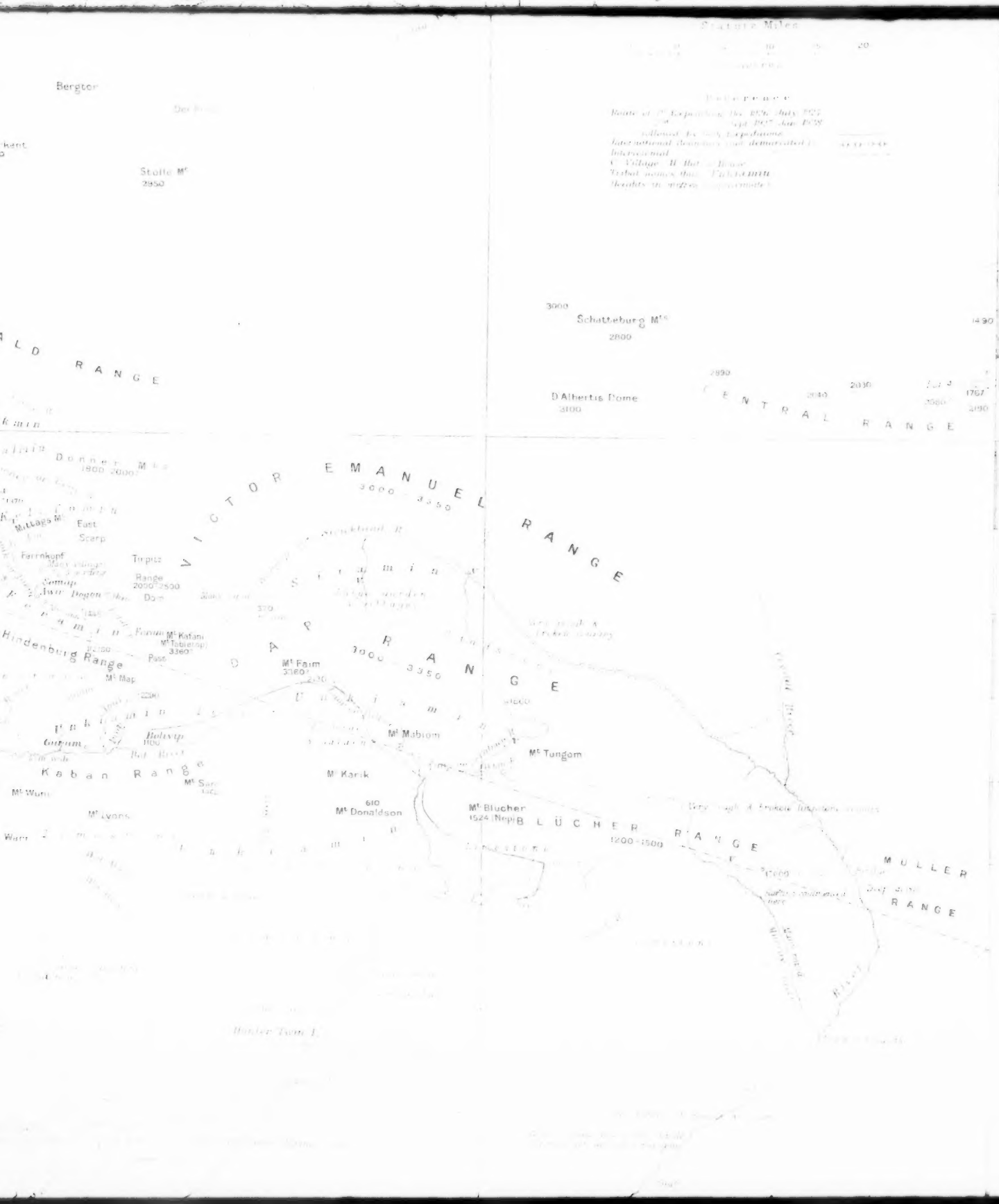
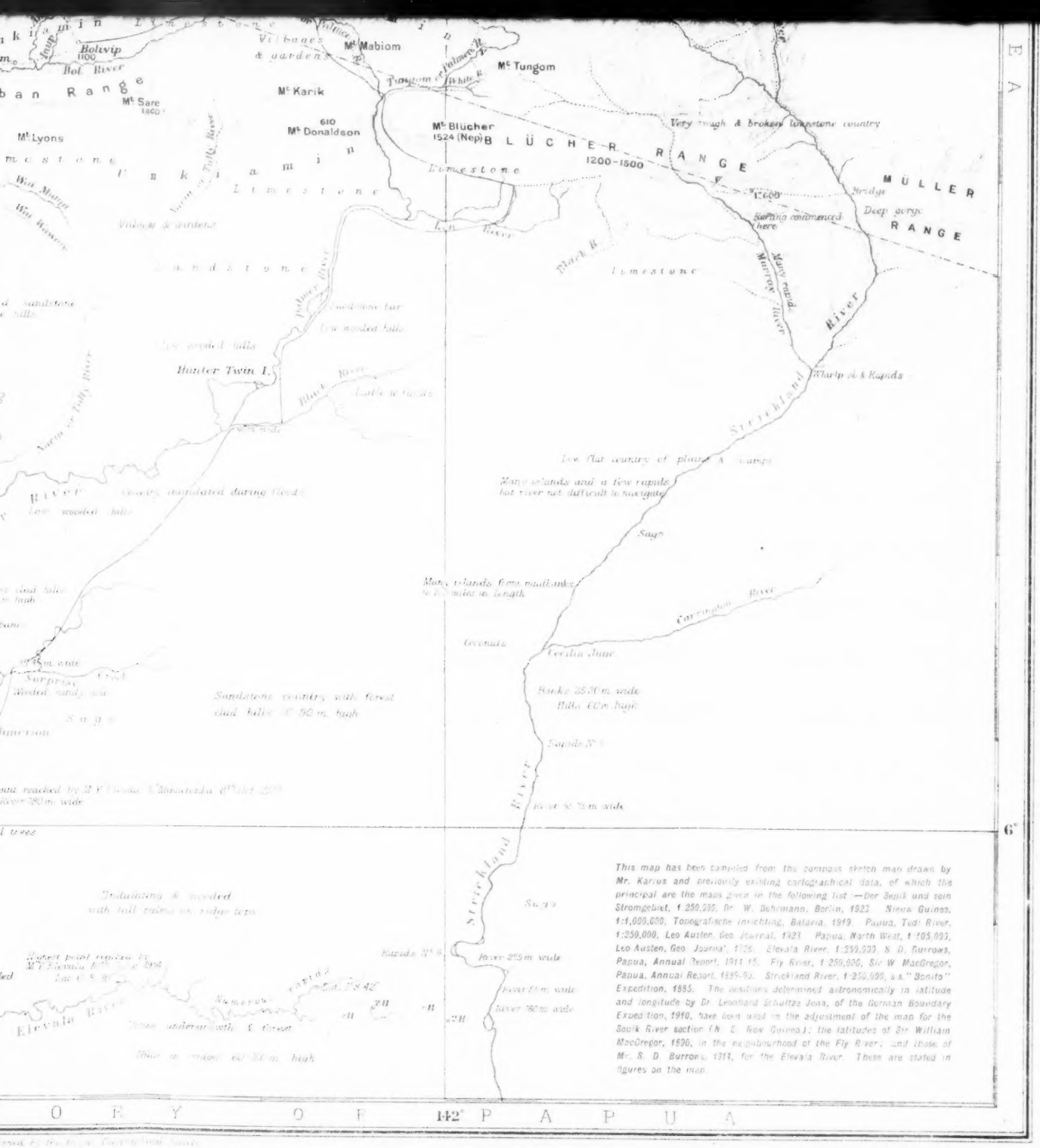
The Explorations of C. H. KARIUS AND L. F. CHAMPION in the crossing of NEW GUINEA from South to North 1926–28




Dunst
Zwillinge
Dubhe
3614
Antares
4170
Scorpion
(Kuswigatu)
3830
Andromeda
2850
Sirrah
2730
Auriga
3880
Capella
3990
Altair
3860
Deneb
2300
Spica
3340
Kahlkopf
Farrnkopf
Spitzkopf
Bluttegel M.
Drei Zinnen
Bambus M.
Wachtkuppe
Spitzenkamm
Wiesenkopf
Hindenburg
THURNWALD
STARMOUNTAINS
Lyra
Virgo
Draden
Pass
Mt. Wurm
Mt. Warn
Langrücken
Die Scharte
Kurzkamm
Mittags M.
Riese


Statute Miles
Bergtor
Stolle Mt
2950
Schatteburg Mts
2800
D'Albertis Dome
3100
CENTRAL RANGE
VICTOR EMANUEL RANGE
Donner Mt
East Scarp
Ferrenkopf
Tirpitz Range
Dom
Hindenburg Range
Mt Kafani
Mt Tobiesip
Pass
Mt Fairn
Mt Map
Mt Mabiom
Mt Tungom
Mt Karik
Kaban Range
Mt Wurm
Mt Lyons
Mt Donaldson
Mt Blucher
BLÜCHER RANGE
MULLER RANGE

NEW GUINEA
DUTCH
TERRITO
Observation Hill
Small villages in sandstone scrub clad hills
Ok Birim
Kol Karuk Worem Karuk
Ok Ledyv
Aduk Biran
Kwit Biran
Gwenbip
Yim Biran
Dimin
Marapka
Murpla
Biwun
Gimbiap
Ort
Waldren I.
Oana
Wam Biran
On Biran
Murugun
Merchrad I.
Sag
Ok Birak or Fly River
Fly River
Plant I
Palmer River
Thomson June
Gogera I.
Macrossan I.
Sandstone bar
Kaban R
Mt Wuni
Mt Lyons
Mt Warr
Unkia
Gukum
Wut Murgi
Wut Kuwen
Thickly wooded
Elevated


Bolivip
1100
Bol River
Mt Mabiom
Villages & gardens
Mt Tungom
Mt Karik
Mt Sare
1960?
Mt Lyons
610
Mt Donaldson
Mt Blücher
1524 (Nep)
BLÜCHER RANGE
1200–1500
Very rough & broken limestone country
MÜLLER
RANGE
1600
Bridge
Deep gorge
Survey commenced here
Limestone
Sandstone
Hunter Twin I.
Strickland River
Whirlp & Rapids
Low flat country of plains & swamps
Many islands and a few rapids but river not difficult to navigate
Sago
Many islands form mudbanks
Corridon River
Cerdin June
Sandstone country with forest
Rapids N° 6
Rapids N° 5
Rapids N° 4
Rapids N° 3
Rapids N° 2
Rapids N° 1
River 215 m wide
River 58 m wide
River 180 m wide
Elevala River
Numerous
Sago
6°
This map has been compiled from the compass sketch map drawn by Mr. Karius and previously existing cartographical data, of which the principal are the maps given in the following list:—Der Sepik und sein Stromgebiet, 1:250,000, Dr. W. Behrmann, Berlin, 1923. Nieuw Guinea, 1:1,000,000, Topografische inrichting, Batavia, 1919. Papua, Tedi River, 1:250,000, Leo Austen, Geo. Journal, 1923. Papua, North West, 1:105,000, Leo Austen, Geo. Journal, 1926. Elevala River, 1:250,000, S. D. Burrows, Papua, Annual Report, 1911-15. Fly River, 1:250,000, Sir W. MacGregor, Papua, Annual Report, 1890-93. Strickland River, 1:250,000, s.s. "Bonito" Expedition, 1895. The positions determined astronomically in latitude and longitude by Dr. Leonhard Schultze Jena, of the German Boundary Expedition, 1910, have been used in the adjustment of the map for the Sepik River section (N. E. New Guinea); the latitudes of Sir William MacGregor, 1890, in the neighbourhood of the Fly River; and those of Mr. S. D. Burrows, 1911, for the Elevala River. These are stated in figures on the map.
O F F O F 142° P A P U A

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